Technical Report GL-97-16
September 1997

US Army Corps of Engineers
Waterways Experiment Station

Conceptual Hydrogeologic Model of Aberdeen Proving Ground—Aberdeen Area

by Charlie B. Whitten, Stanley M. Swartzel, S. Paul Miller, WES
Kelly Blough, Advanced Sciences, Inc.

Prepared for Directorate of Safety, Health, and Environment
Aberdeen, Maryland

Technical Report GL-97-16
September 1997

Conceptual Hydrogeologic Model of Aberdeen Proving Ground—Aberdeen Area

by Charlie B. Whitten, Stanley M. Swartzel, S. Paul Miller

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Kelly Blough

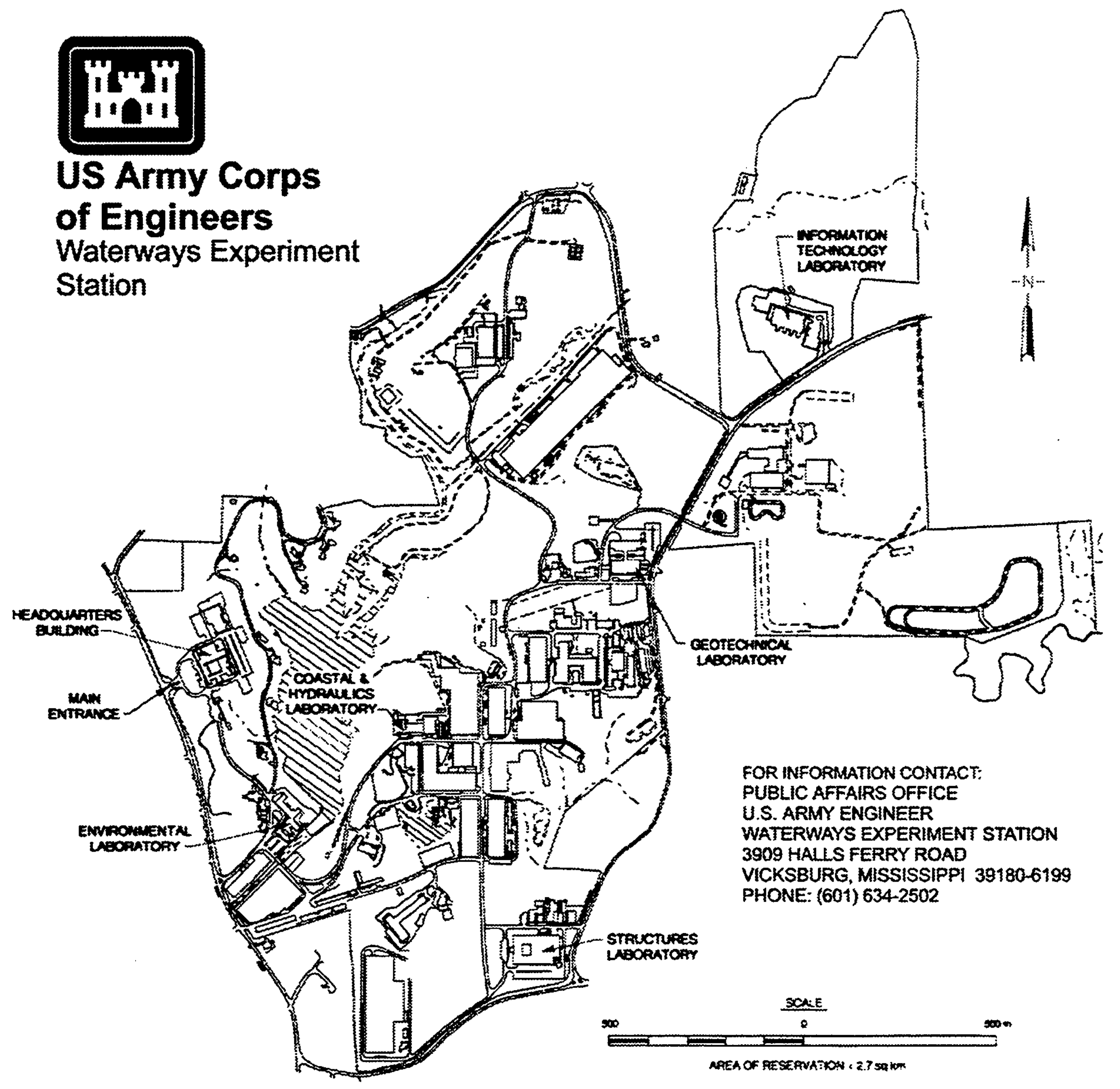
Advanced Sciences, Inc.
HQ USAADACENFB
ATT: ZC-DOE-M 515B Blough
Fort Bliss, TX 79916

Final report

Approved for public release; distribution is unlimited

Prepared for Environment Management Division
Directorate of Safety, Health, and Environment
Aberdeen Proving Ground
Aberdeen, MD

US Army Corps of Engineers
Waterways Experiment Station



Waterways Experiment Station Cataloging-in-Publication Data

Conceptual hydrogeologic model of Aberdeen Proving Ground, Aberdeen area / by Charlie B. Whitten ... [et al.] ; prepared for Environment Management Division, Directorate of Safety, Health, and Environment, Aberdeen Proving Ground.
228 p. : ill. ; 28 cm. — (Technical report ; GL-97-16)
Includes bibliographic references.
1. Hydrogeology. 2. Groundwater. 3. Aquifers. 4. Aberdeen Proving Ground (Md.) I. Whitten, Charlie B. II. United States. Army. Corps of Engineers. III. U.S. Army Engineer Waterways Experiment Station. IV. Geotechnical Laboratory (U.S. Army Engineer Waterways Experiment Station) V. Aberdeen Proving Ground (Md.). Environmental Management Division. VI. Aberdeen Proving Ground (Md.). Directorate of Safety, Health, and Environment. VII. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; GL-97-16.
TA7 W34 no.GL-97-16

Contents

List of Figures

List of Tables

Preface

This study was performed during the period July 1994 to July 1997 by the U.S. Army Engineer Waterways Experiment Station (WES) for the Environmental Management Division, Directorate of Safety, Health, and Environment, Aberdeen Proving Ground (APG), Aberdeen, MD. The work was performed under the authority provided by Project Order Numbers PO 94-13 and PO 96-288. The report was completed in 1997. Subsequent and on-going field investigations will provide additional data about the APG -Aberdeen Area that should be added to this report.

The data were collected and assembled by Messrs. Charlie B. Whitten, Stanley M. Swartzel, and S. Paul Miller, Engineering Geology Branch (EGB), Earthquake Engineering and Geosciences Division (EEGD), Geotechnical Laboratory (GL), WES, and Mr. Kelly Blough, Advanced Sciences, Inc (ASI). Direct supervision was provided by Mr. Joe L. Gatz and Dr. Lillian D. Wakeley, former Chief and Chief, respectively, EGB. The project was conducted under the supervision of Dr. A. G. Franklin, Chief, EEGD, and Dr. W. F. Marcuson III, Director, GL.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin.

Executive Summary

Introduction

This report brings together the hydrogeologic data gathered during numerous site-specific investigations conducted on Aberdeen Proving Ground-Aberdeen Area (APG-AA) and nearby areas into a conceptual hydrogeologic model of APG-AA and adjacent areas.

Site Location and Setting

The Aberdeen Proving Ground (APG) is located on the northwestern shore of the Chesapeake Bay, approximately 15 miles northeast of Baltimore, MD. The APG, which includes the APG-Edgewood Area (APG-EA) APG-EA and APG-AA, occupies a total of 79,000 acres, including land and water, of Baltimore and Harford Counties. The APG-AA occupies approximately 17,000 acres of land on a peninsula approximately 3 miles south-southwest of the mouth of the Susquehanna River. The peninsula is bordered by Swan Creek to the north, Chesapeake Bay to the east, and Bush River to the west and southwest.

Ground Surface

The surface of APG-AA is characterized by low lying, gently rolling terrain. The surface in the western half of APG-AA, generally west of Michaelsville and Old Baltimore roads, has a well drained soil that gently slopes to the south from about elevation (el) 70 ft msl in the north to 0 ft msl at Bush River. The surface in the eastern half of APG-AA is low lying, flat, and poorly drained soils that slope to the east-southwest from about el 25 to 30 ft msl along the western edge of the Quaternary terrace 2 (Qt2) surface to 0 ft msl at Chesapeake Bay and Bush River. The surface is characterized by low lying, relatively flat, swampy areas separated by low rolling ridges only a few feet higher in elevation than the swampy areas.

Geologic Setting

APG-AA is in the Coastal Plain Physiographic Province, which is bounded by the metamorphic rocks of the Piedmont Province to the west and the Atlantic Ocean to the east. The Coastal Plain sediments at APG-AA have been

previously mapped as consisting of three major units, the Lower Cretaceous Potomac group, the Pleistocene Talbot Formation, and Recent (Holocene) sediments. The Potomac Group, which is comprised of the Patuxent, Arundel, and Patapsco formations in Harford County, uncomformably overlie the Precambrian basement rock. Most of the surface of APG-AA has been mapped as the Pleistocene Talbot formation in geologic reports. Geologic data from recent studies on APG-AA have shown that the Talbot Formation on APG-AA is a series of three Quaternary terraces, labeled from youngest to oldest as Qt1, Qt2 and Qt3. Recent (Holocene) sediments are located along the drainages and shoreline.

Groundwater

Groundwater data on APG-AA are limited primarily from ground surface to about 200 ft below ground surface with the majority of the data from 0 to 100 ft below ground surface. The data are also concentrated in the area between the APG-AA western boundary and Old Baltimore-Michaelsville roads. The coarse grained Qt3 sediments form a very permeable water table aquifer 40 to 60 ft thick along the western edge of APG-AA. The Qt2 Unit C forms a water table aquifer that varies from lenses of permeable medium- to fine-grained silty sands to impermeable clay lenses. The Qt2 Unit C varies from a water table aquifer to a confined or semiconfined aquifer in the area of Michaelsville Landfill (MLF). Qt2 Unit B acts as an aquitard. Qt2 Unit A has permeable coarse-grained sediments, however there are insufficient data to characterize this unit.

The Cretaceous sediments are primarily interbedded sands, silts, and clays. Permeable sandy aquifers could be correlated along strike on the western boundary of APG-AA. There are eight Harford County production wells, which produce approximately 3.5 million gallons per day (mgd), screened in the Cretaceous aquifers along the western boundary of APG-AA. Groundwater flow patterns in the Qt3 and the response of the monitor wells screened in the Qt3 near the Harford County production wells, show the production wells are pumping a significant volume of the 3.5 mgd from the Qt3. There are no data showing how much of the 3.5 mgd comes from the Qt3 or the Cretaceous aquifer.

There are numerous monitor well (three wells per cluster) and piezometer (two per cluster) clusters in the area between the APG-AA western boundary and Old Baltimore-Michaelsville roads. A comparison of the water level data from the water table wells and the wells screened in the Cretaceous show the permeable units in the Cretaceous are poorly connected laterally and vertically.

Data Gaps

The bulk of the geologic/hydrogeologic data on APG-AA are concentrated in the area between the western APG-AA boundary and the Old Baltimore and Michaelsville roads. The area east-southeast of Old Baltimore and Michaelsville roads is primarily test firing ranges with very limited access. Geologic/hydrogeologic data from the range areas are limited to a few shallow monitor wells and borings. Additional geologic/hydrogeologic data from this

area would be helpful in order to better define:

a. horizontal and vertical extent of the QT1 and QT2 Quaternary terraces
b. lithologies of the QT1 and QT3 terraces
c. groundwater flow
d. Cretaceous surface
e. lithologies of the Cretaceous units

Surface water flow data on APG-AA are limited to data from two sites on Mosquito Creek. Base flows and runoff data should be collected from all the streams on APG-AA. Streamflow data could be used to delineate which segments of each stream are losing or gaining and under what conditions. Comparison of the streamflow data and the synoptic water level data being collected could be used to determine the effect of the groundwater extraction systems on the Aberdeen Peninsula. The streamflow data would be useful to natural resource management and enhancement.

The existing 1927 soils map of APG-AA should be updated to better define the soil characteristics on APG-AA. This would aid in the better understanding of the vertical movement of possible contaminants through the surficial soils. This is an important aspect of environmental studies.

Previous investigations in the APG-AA area have not been able to confidently differentiate the Cretaceous formations. Dunbar et al. (1997)[1] used some very limited data to partially differentiate some of the Cretaceous formations. Clay mineralogy, heavy mineral, and pollen analyses of the Cretaceous materials may allow the identification and complete correlation of the Cretaceous formations. This could be very important in helping determine whether or not a possible route exists for contaminants to migrate under the Chesapeake Bay from APG-AA to the Delmarva Peninsula.

---

[1] Complete reference information follows main text.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI as follows:

Multiply	By	To Obtain
acres	4,046.873	square metres
acres	0.4047	hectares
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]
feet	0.3048	metres
feet per mile	0.1894	metres per kilometre
gallons (US liquid)	3.7853	litres
inches	0.0254	metres
miles (US statute)	1.6093	kilometres
square miles	2,589,998	square metres
yards	1.0936	metres

[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula : $C = (5/9)(F-32)$. To obtain Kelvin (K) readings, use $K = (5/9)(F-32) + 273.15$.

1 Introduction

Objective

This report is a review and compilation of hydrogeologic data gathered during multiple, site-specific investigations conducted on Aberdeen Proving Ground-Aberdeen Area (APG-AA) and nearby areas. This is an initial attempt to unify the widely disparate data and to synthesize a conceptual hydrogeologic model of APG-AA and adjacent areas. The results of this holistic approach will be used to focus later environmental investigations at APG-AA, standardize data collection, and improve the efficiency of the ongoing environmental remediation process.

Site Location

The Aberdeen Proving Ground (APG) is located on the Chesapeake Bay, approximately 15 miles northeast of Baltimore, MD (Figure 1). The total land and water area of APG is approximately 79,000 acres (123 sq miles) of Baltimore and Harford Counties. It is divided into two areas, the Edgewood Area (APG-EA) and the APG-AA (Figure 2). The land area of APG-AA occupies approximately 17,000 acres (approximately 26 sq miles) of Harford County.

Site Setting

APG-AA is on the northwestern shore of the Chesapeake Bay and is surrounded by three large bodies of water: Chesapeake Bay, Swan Creek, and Bush River (Figure 3). The Chesapeake Bay forms the eastern edge of APG-AA. Swan Creek enters the Chesapeake Bay forming the northeastern border of APG-AA. Bush River enters the Chesapeake Bay at the southern most tip of APG-AA and forms part of the western border.

APG-AA is drained by eight rivers and streams (Figure 3). Surface waters on APG-AA tend to be shallow and sluggish with tidal estuaries forming at the mouths of the streams and rivers. This is attributed to the low elevations of the area and the fact that it is bordered by the Chesapeake Bay estuary (Environmental Science and Engineering, Inc. (ESE) 1981). The northern

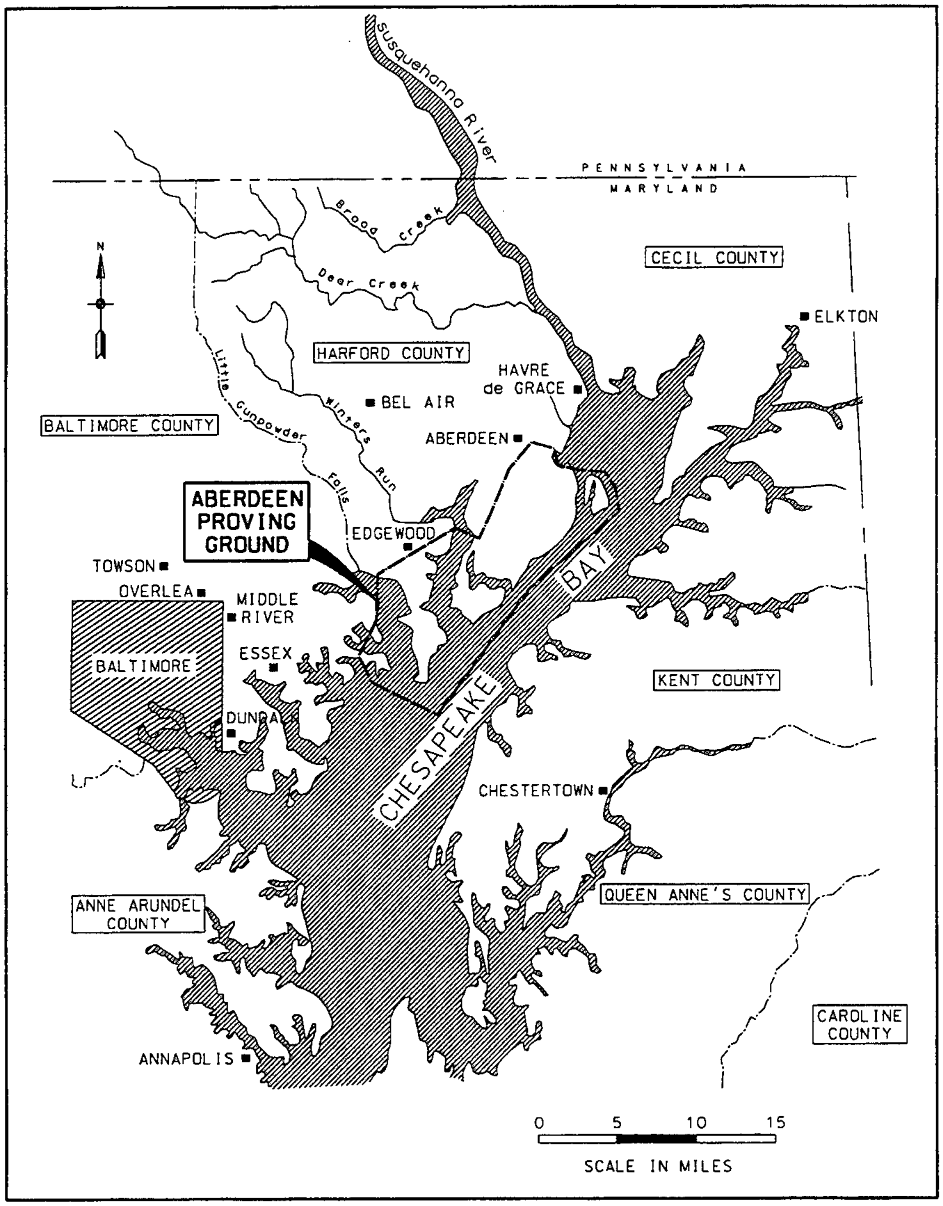


Figure 1. Location of Aberdeen Proving Ground, MD

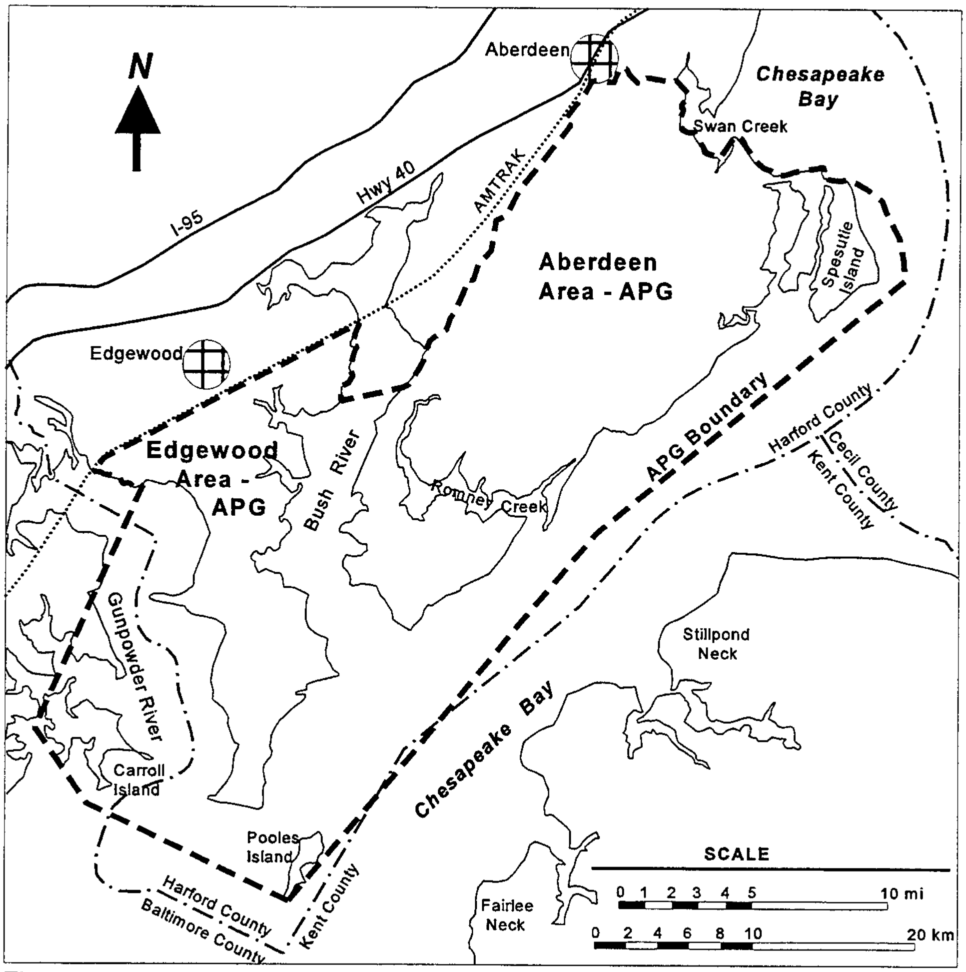


Figure 2. Map of Aberdeen Proving Ground

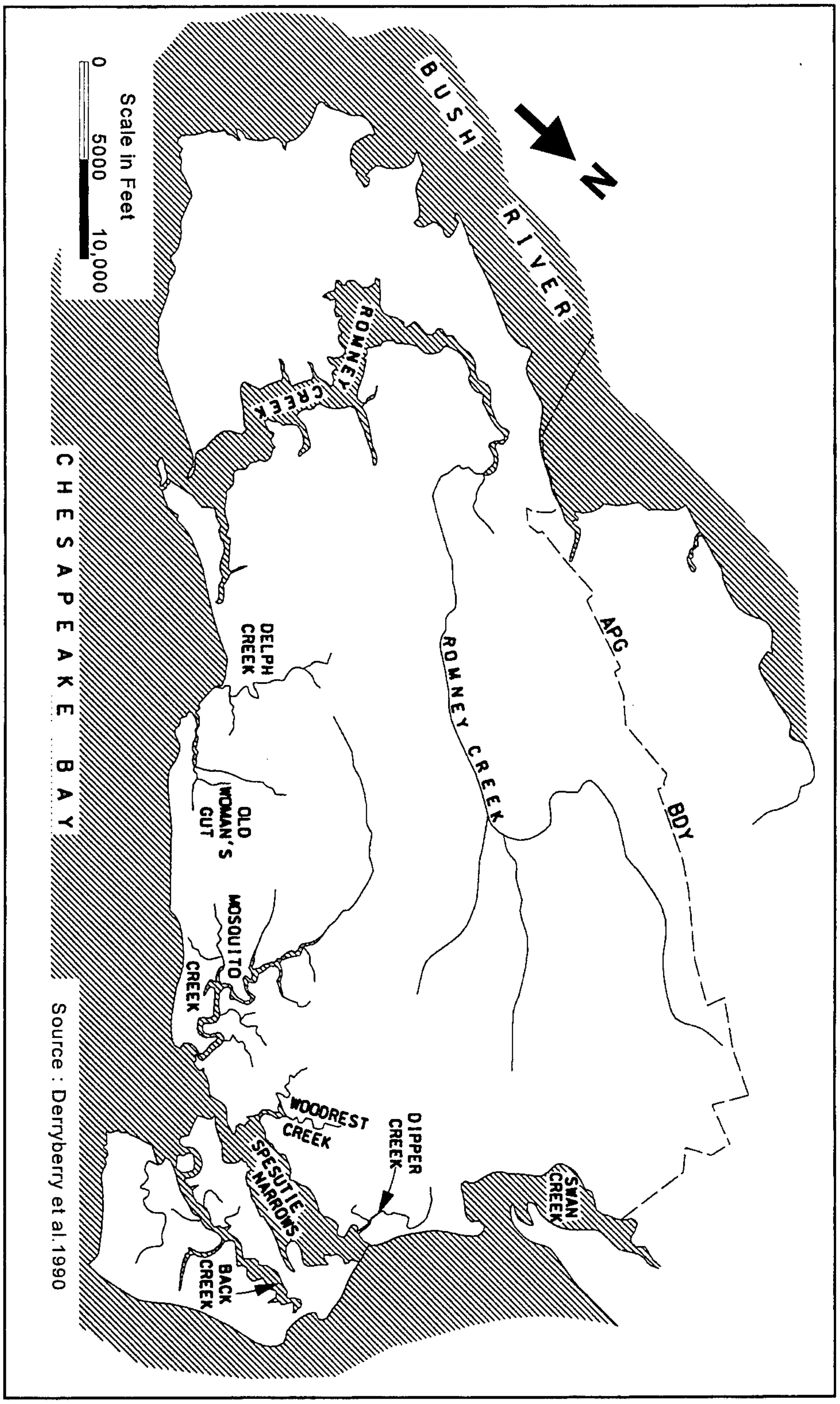


Figure 3. Rivers and streams draining APG-AA

portion of APG-AA, where the administrative and industrial operations are located, is drained by Swan Creek, Dipple Creek, Woodrest Creek, and the upper branches of Romney Creek. The southern portion, which is mostly undeveloped ranges and test areas, is drained by Mosquito Creek, Delph Creek, Old Women's Gut, and the lower half of Romney Creek. Spesutie Island, which is mostly unimproved ranges and test areas, is drained by Back Creek.

The climate of APG-AA is temperate and moderately humid. Due to the proximity of two large bodies of water, the Chesapeake Bay and the Atlantic Ocean, the climate is moderate as compared to the inland areas (ESE 1981). The average temperature at APG-AA is approximately 55° F (Figure 4), with an average relative humidity of approximately 75 percent. Precipitation, as rainfall, averaged approximately 48 in. per year during the period from 1949 through 1996 with the maximum rainfall occurring in the summer and the minimum during the winter (Figure 5 and 6). Precipitation, as snowfall, averages approximately 11 in. per year. Prevailing winds average 6.8 knots (Sisson, 1985) in a northwest to north-northwesterly direction in the winter months and a south to south-southwesterly direction in the summer months (ESE 1981).

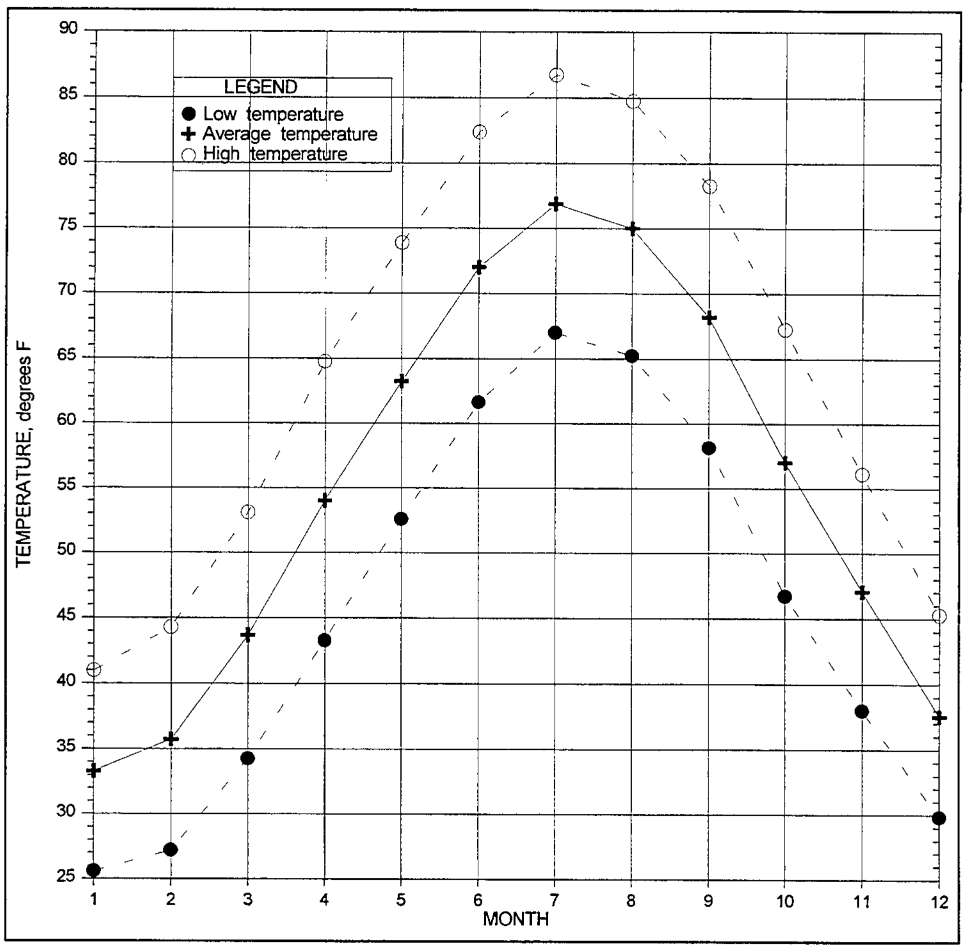


Figure 4. Average monthly temperature recorded at PAAF from 1948 through 1996. The average monthly high and low temperatures are also shown

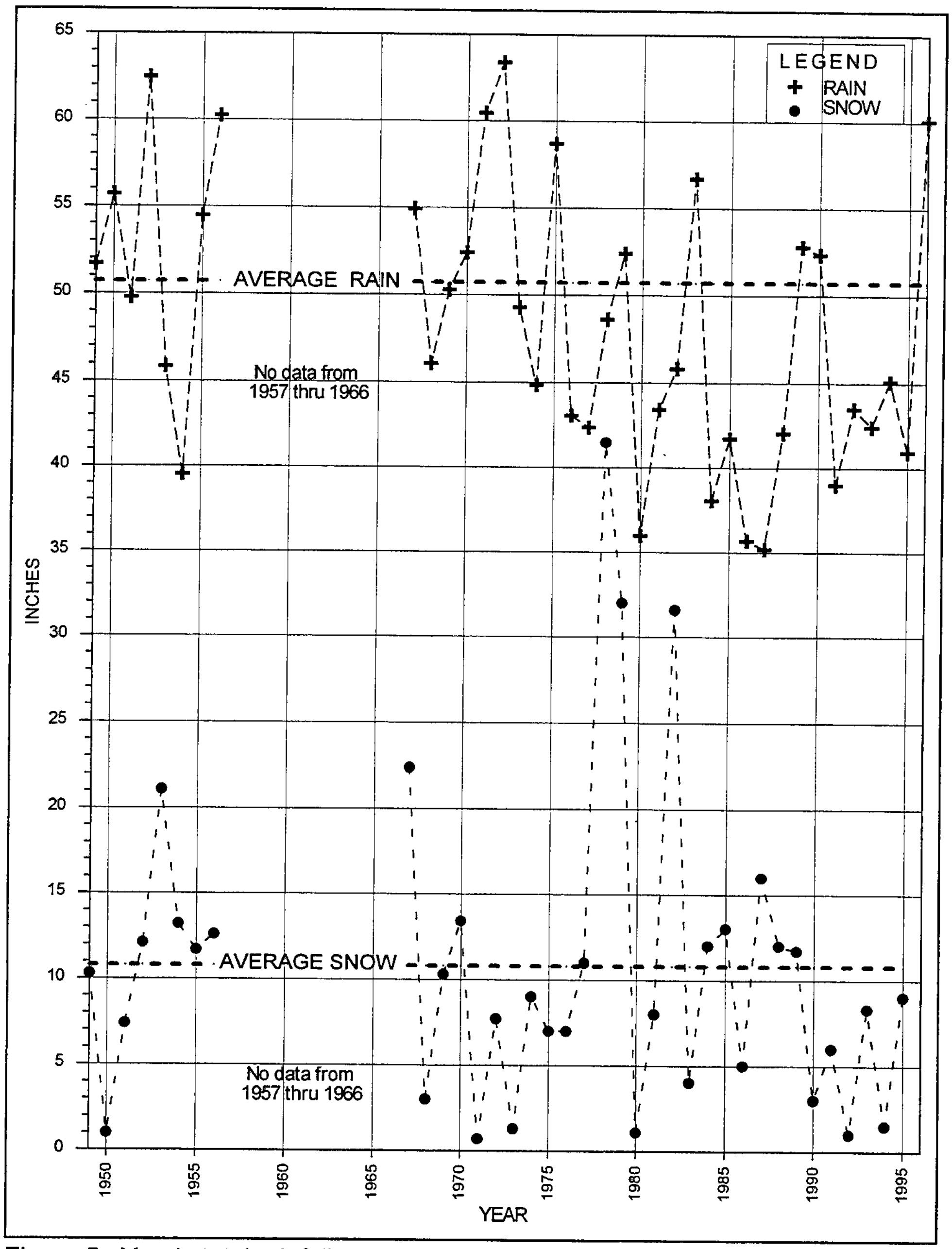


Figure 5. Yearly total rainfall and snowfall recorded at PAAF

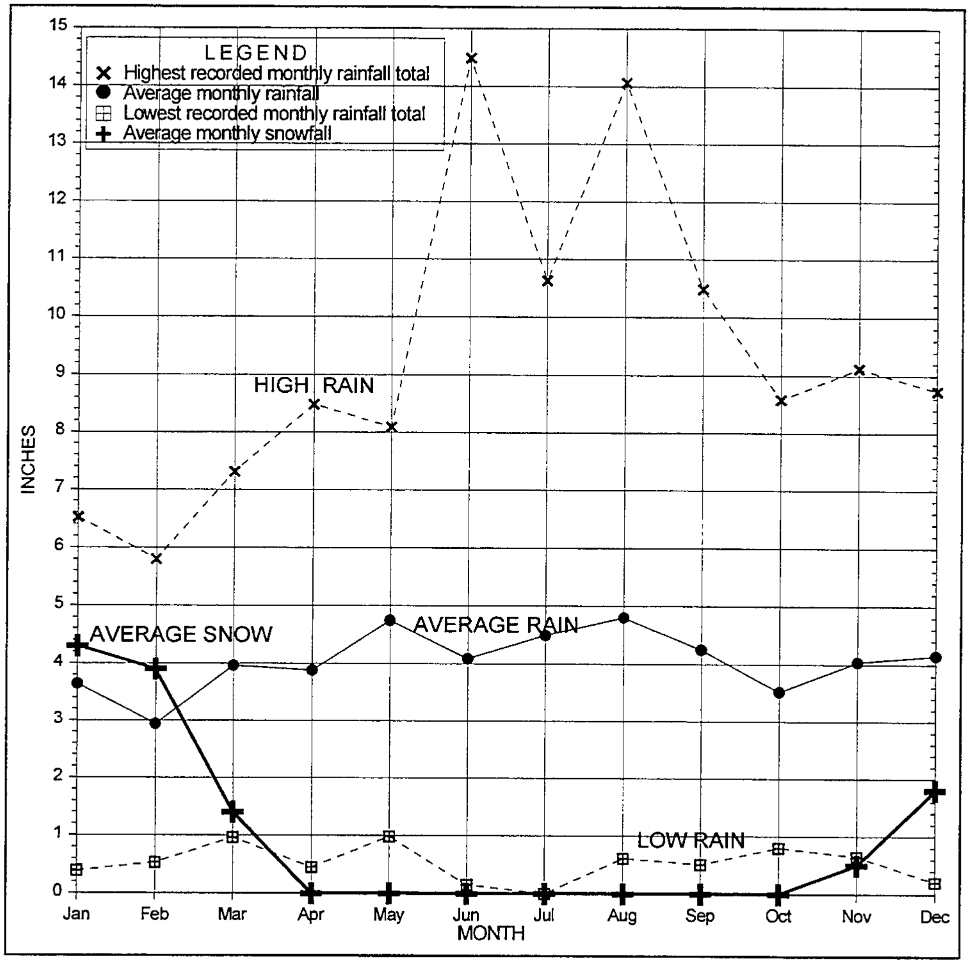


Figure 6. Average recorded rainfall and snowfall data at PAAF. The average for rainfall and snowfall includes only those years from 1948 through 1996 that data were collected for all 12 months. The highest and lowest recorded rainfall data for each month includes all data from 1948 through 1996.

The APG-AA Meteorological Laboratory maintains data collection stations on APG. The primary site was located on Spesutie Island near Locust Point. The data collection station is now located at Phillips Army Airfield (PAAF) in the central portion of APG-AA. Continuous monitoring of meteorological parameters are conducted at this site. Total monthly rainfall and snowfall data collected at APG-AA from August 1948 through September 1996 are presented in Tables 1 and 2, respectively. Daily rainfall data are in Appendix A.

TABLE 1
Rainfall Data Recorded at PAAF from 1948 through 1996

YEAR	MONTHLY RAIN FALL												YEAR TOTAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1948	no	no	no	no	no	no	no	2.38	2.82	1.63	4.83	5.60	****
1949	7.61	3.71	2.93	3.86	6.61	0.63	4.64	5.05	5.65	4.46	2.42	4.12	51.69
1950	4.12	5.21	5.91	3.38	7.98	3.25	3.55	5.02	6.41	3.45	3.62	3.79	55.69
1951	4.32	5.45	4.93	2.23	3.64	6.29	4.29	1.62	1.08	2.88	6.68	6.37	49.78
1952	7.51	3.42	5.86	9.67	7.23	3.91	4.39	5.32	3.90	1.50	5.50	4.28	62.49
1953	6.91	3.37	5.23	5.39	6.64	2.96	3.09	1.62	1.77	3.00	1.98	3.89	45.85
1954	2.09	0.62	4.00	4.34	4.38	0.60	2.36	5.82	3.60	3.60	3.72	4.39	39.52
1955	3.66	4.74	6.06	5.44	2.00	6.82	1.17	14.76	2.56	4.60	2.00	0.66	54.47
1956	3.71	5.18	5.01	3.14	2.80	5.14	6.35	5.23	3.62	4.25	9.84	5.98	60.25
1957	3.48	4.54	6.47	4.56	3.15	5.92	2.44	3.58	6.77	2.74	3.41	no	****
	No climatic data collected at PAAF from December 1957 through May 1966												
1966	no	no	no	no	no	0.77	1.80	2.32	7.12	3.56	3.53	5.82	****
1967	2.32	1.77	4.57	2.57	5.47	6.17	5.02	13.62	0.51	2.20	3.31	7.38	54.91
1968	2.87	0.66	6.83	2.34	7.14	2.99	3.25	7.23	2.43	3.50	4.67	2.17	46.08
1969	2.80	2.31	1.86	2.58	1.81	4.27	6.43	4.22	11.57	1.56	2.13	8.73	50.27
1970	0.95	2.68	4.18	6.36	2.33	7.33	9.13	3.74	1.18	4.62	6.43	3.49	52.42
1971	2.94	6.79	1.77	2.65	7.41	2.64	5.06	14.97	4.49	6.98	4.27	0.87	60.84
1972	4.40	5.06	4.30	5.14	4.45	6.42	4.97	3.28	1.92	6.05	9.00	8.41	63.40
1973	2.81	2.66	3.81	6.91	5.45	4.75	2.97	5.25	3.96	2.67	0.74	7.30	49.28
1974	2.93	1.04	3.33	3.26	4.67	3.03	4.04	5.69	6.96	2.15	2.38	5.37	44.85
1975	3.94	2.39	3.89	2.96	5.63	8.76	10.63	3.72	9.94	2.49	3.13	1.21	58.69
1976	6.15	1.28	1.01	3.07	5.55	1.24	4.79	4.81	3.90	8.58	0.65	2.06	43.09
1977	1.64	0.62	4.37	3.93	1.14	7.31	2.13	5.49	0.93	3.76	4.71	6.35	42.38
1978	6.38	0.66	4.95	1.41	7.36	1.74	5.10	9.48	3.49	0.94	2.93	4.18	48.62
1979	6.17	6.32	1.95	3.43	3.76	3.82	3.92	5.33	6.45	5.52	4.27	1.45	52.39
1980	1.61	0.68	5.82	3.51	3.78	6.86	2.28	2.82	1.50	3.59	2.95	0.58	35.98
1981	0.39	3.35	1.39	5.30	3.52	5.77	4.28	2.81	4.94	3.54	2.80	5.37	43.46
1982	4.88	3.17	1.96	6.01	4.77	6.20	2.65	3.33	3.24	2.87	4.04	2.70	45.82
1983	2.60	3.22	7.31	8.48	4.80	5.81	0.00	4.36	2.09	4.60	5.01	8.41	56.69
1984	1.16	3.99	3.94	3.63	5.40	3.13	5.06	1.48	1.68	3.67	3.15	1.79	38.08
1985	1.32	2.63	2.38	0.45	4.25	4.99	6.58	3.99	6.35	3.17	3.43	2.20	41.74
1986	2.36	3.58	0.96	2.44	1.41	2.58	1.48	3.41	1.08	3.05	6.71	6.64	35.70
1987	4.13	1.02	1.49	1.40	3.89	2.53	2.95	1.60	9.18	1.88	2.94	2.18	35.19
1988	2.77	4.09	2.07	2.80	6.90	0.40	5.56	5.60	3.17	2.66	5.14	0.91	42.07
1989	2.81	3.30	5.28	2.72	8.09	6.82	7.50	1.34	5.06	5.80	1.51	2.57	52.80
1990	5.83	1.38	1.83	3.85	8.60	5.65	4.32	7.59	2.37	2.83	2.79	5.31	52.35
1991	4.42	1.89	3.85	2.55	2.50	0.87	3.98	5.23	5.73	2.92	1.68	3.38	39.00
1992	0.93	2.45	4.24	4.56	3.69	2.61	4.63	3.99	5.21	2.91	4.29	4.00	43.51
1993	2.26	2.40	6.65	5.44	2.03	3.18	4.32	1.59	5.89	1.80	2.43	4.46	42.45
1994	5.59	3.79	6.34	2.33	3.80	0.76	10.09	4.32	2.46	0.80	2.97	1.84	45.09
1995	4.14	1.36	1.53	2.75	5.23	4.48	3.49	0.01	5.38	6.22	4.02	2.36	40.97
1996	5.09	1.84	4.24	4.45	5.47	4.37	8.80	3.82	5.96	3.52	3.42	7.25	60.06
	MONTHLY AVERAGE												YEAR AVER.
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
	3.64	2.94	3.96	3.88	4.74	4.09	4.49	4.80	4.25	3.52	4.04	4.15	50.71

no — No climatic data were collected at PAAF　　**** --- 12 months data not collected

"**MONTHLY AVERAGE**" includes all data　　Rainfall data are in inches

"**YEAR AVER.**" includes only those years data were collected for all 12 months

TABLE 2
Snowfall Data Recorded at PAAF from 1948 through 1996

Year	MONTHLY SNOWFALL							YEAR TOTAL
	JAN	FEB	MAR	APR	MAY-OCT	NOV	DEC	
1948	no	no	no	no			7.0	****
1949	1.3	9.0						10.3
1950						1.0		1.0
1951	1.0	0.4					6.0	7.4
1952	7.0		4.1				1.0	12.1
1953	8.5	0.1	4.0			8.5		21.1
1954	11.7	1.1					0.4	13.2
1955	2.5	7.0	1.2			1.0		11.7
1956	4.8	0.1	7.6	0.1				12.6
1957	9.2	5.5	1.0				no	****
	No climatic data collected at PAAF from December 1957 through May 1966							
1966	no	no	no	no			21.6	****
1967	0.5	15.6				5.0	1.3	22.4
1968	2.0		1.0					3.0
1969		2.0	2.0				6.3	10.3
1970	8.9	3.5					1.0	13.4
1971	0.7							0.7
1972	2.0	5.7						7.7
1973		1.3						1.3
1974	2.5	6.5						9.0
1975	4.0	3.0						7.0
1976	3.0	1.0	3.0					7.0
1977	11.0							11.0
1978	9.0	13.0	17.0			2.5		41.5
1979	2.0	30.0						32.0
1980		1.0					0.1	1.1
1981	7.0		1.0					8.0
1982	11.5	7.1					13.0	31.6
1983		4.0						4.0
1984	8.0		4.0					12.0
1985	12.0						1.0	13.0
1986	1.0	4.0						5.0
1987	3.0	12.0					1.0	16.0
1988	12.0							12.0
1989	5.0	1.0					5.7	11.7
1990							3.0	3.0
1991	6.0							6.0
1992		1.0						1.0
1993		4.0	3.0				1.3	8.3
1994	0.5	1.0						1.5
1995		5.0				1.0	3.0	9.0
1996	9.0	9.0	5.0			NA	NA	****

	MONTHLY AVERAGE						YEAR AVER.
	JAN	FEB	MAR	APR through OCT	NOV	DEC	
	4.3	3.9	1.4		0.5	1.8	10.8

no — No climatic data were collected at PAAF
NA — Data no yet available
**** — 12 months data not collected
Blank spaces are "0" values.
"**MONTHLY AVERAGE**" includes all data
Data are in inches.
"**YEAR AVER**"-- includes only those years data were collected for all 12 months

2 Data Collection

Literature Review

Maryland extends across five physiographic regions, the Appalachian Plateau, Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain Provinces (Figure 7). These physiographic regions parallel the Atlantic shore in belts of varying width. The APG-AA is located on the western edge of the Coastal Plain Province of Maryland. The metamorphic rocks of the Piedmont Province form the basement of the APG-AA.

Coastal Plain Province

The Coastal Plain is a low-lying area of mostly unconsolidated sediments bounded on the west by the Piedmont Physiographic Province. The boundary between the Coastal Plain and Piedmont Provinces is known as the Fall Line, an irregular line or zone of contact along which the Coastal Plain sediments overlap the rocks of the Piedmont. The eastern boundary of the Coastal Plain is generally considered to be the Atlantic Ocean, with the understanding that these sediments extend into the ocean beneath sediments more recently deposited onto the continental shelf.

During Cretaceous to Quaternary time, a part of the continental terrace of the eastern United States (U.S.) was exposed above sea level as a result of large-scale epeirogenic movements. As a result, the emerged Atlantic Coastal Plain underwent extensive fluvial dissection, producing the present topography of the region (Doering 1960). Over the years, numerous investigations of the Coastal Plain have been conducted. Some of the investigations which encompass the entire Coastal Plain are Richards (1948), LeGrand (1961), Maher (1965), the U.S. Geological Survey (USGS) (1967) , and Brown, Miller, and Swain (1972).

The Coastal Plain in Delaware, the District of Columbia, and Maryland (Figure 8) encompasses an area of approximately 8,500 sq miles (Vroblesky and Fleck 1991). This area is underlain by a series of eastward- and southeastward-dipping deposits of mostly unconsolidated sands, silts, clays , and gravels. These sediments form a wedge-shaped, eastward-thickening body which overlies a basement complex of Precambrian to Paleozoic crystalline rocks and Mesozoic rift-basin sedimentary rocks. The Coastal Plain sediments of this area range in

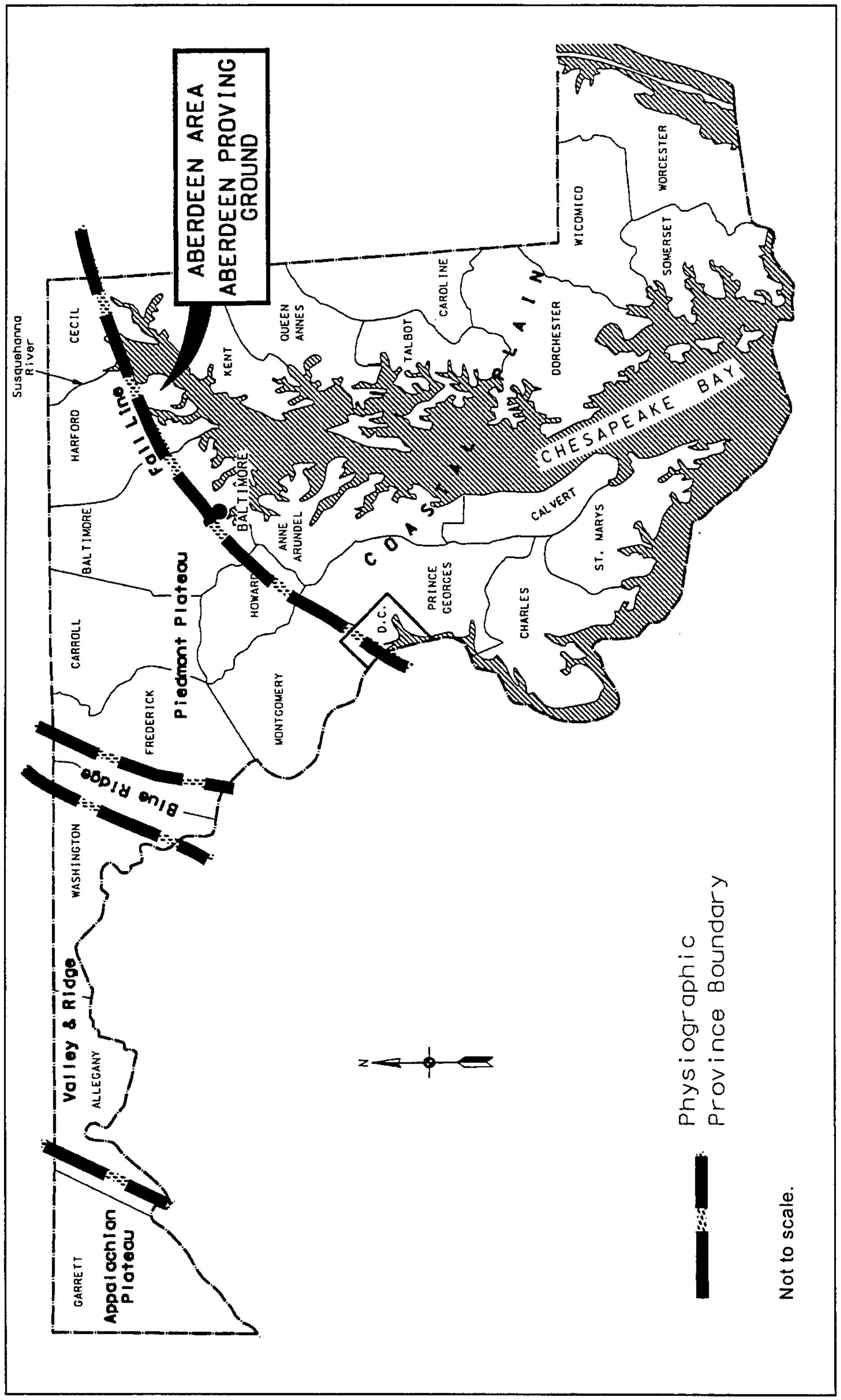


Figure 7. Physiographic provinces in the state of Maryland

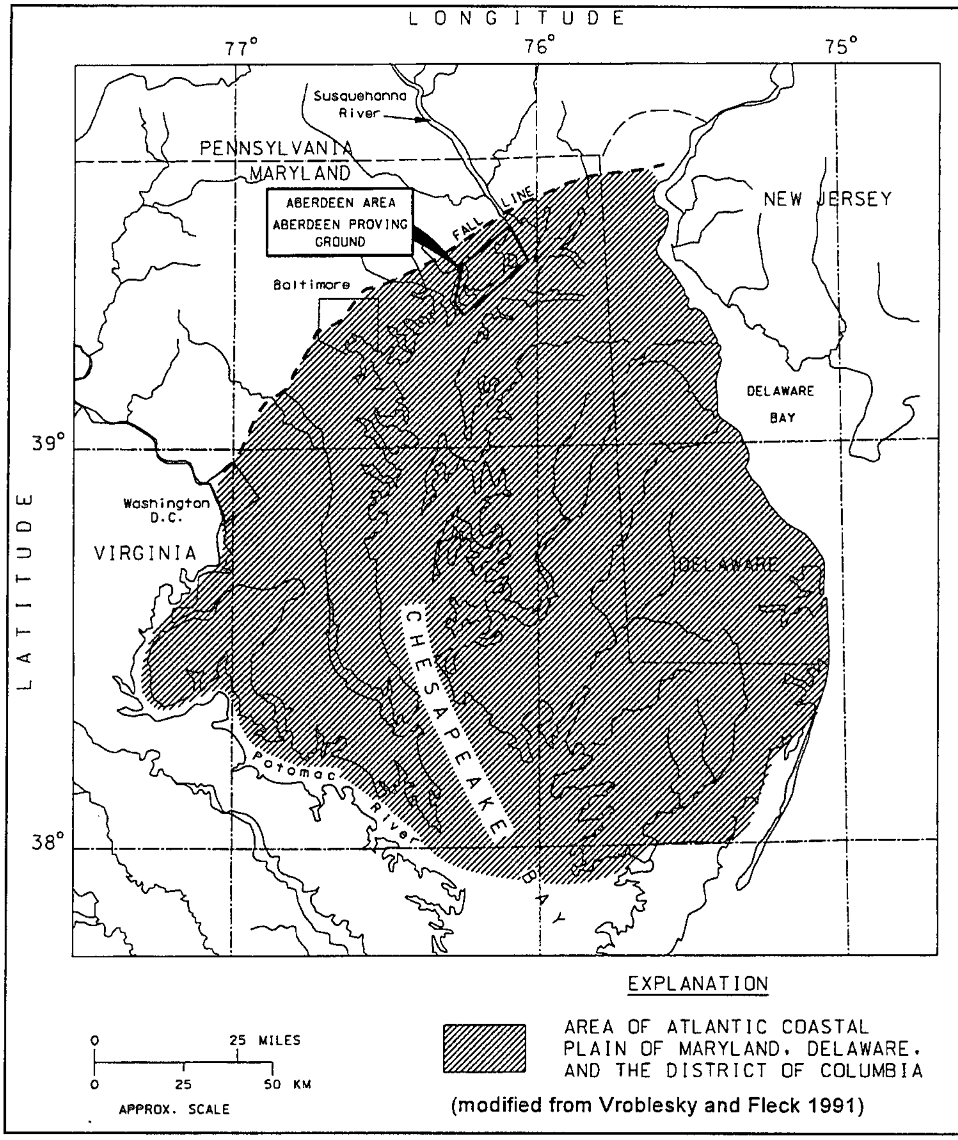


Figure 8. Coastal Plain in Delaware, Maryland, and the District of Columbia

thickness from 0 ft at the Fall Line to approximately 7,700 ft at Ocean City, MD (Hansen and Edwards 1986).

Coastal Plain in Maryland

Maryland's Coastal Plain consists of marine and nonmarine sediments lying unconformably on the eastern continuation of the Piedmont Crystalline Complex. The Piedmont rocks are largely metamorphosed sedimentary and igneous rocks which are typically finely crystalline, very micaceous rocks containing abundant quartz and albitic plagioclase (Owens 1969). Rock types include gabbro, amphibolite, mafic gneiss, felsic schist, felsic gneiss , and quartz monzonite. Owens (1969) indicates the surface of the basement rocks found beneath the Coastal Plain in the Maryland-Delaware-Virginia area forms a deep east-southeast plunging trough with an axis approximately perpendicular to the existing Appalachian structural trend (Figure 9). This basement down-warp is

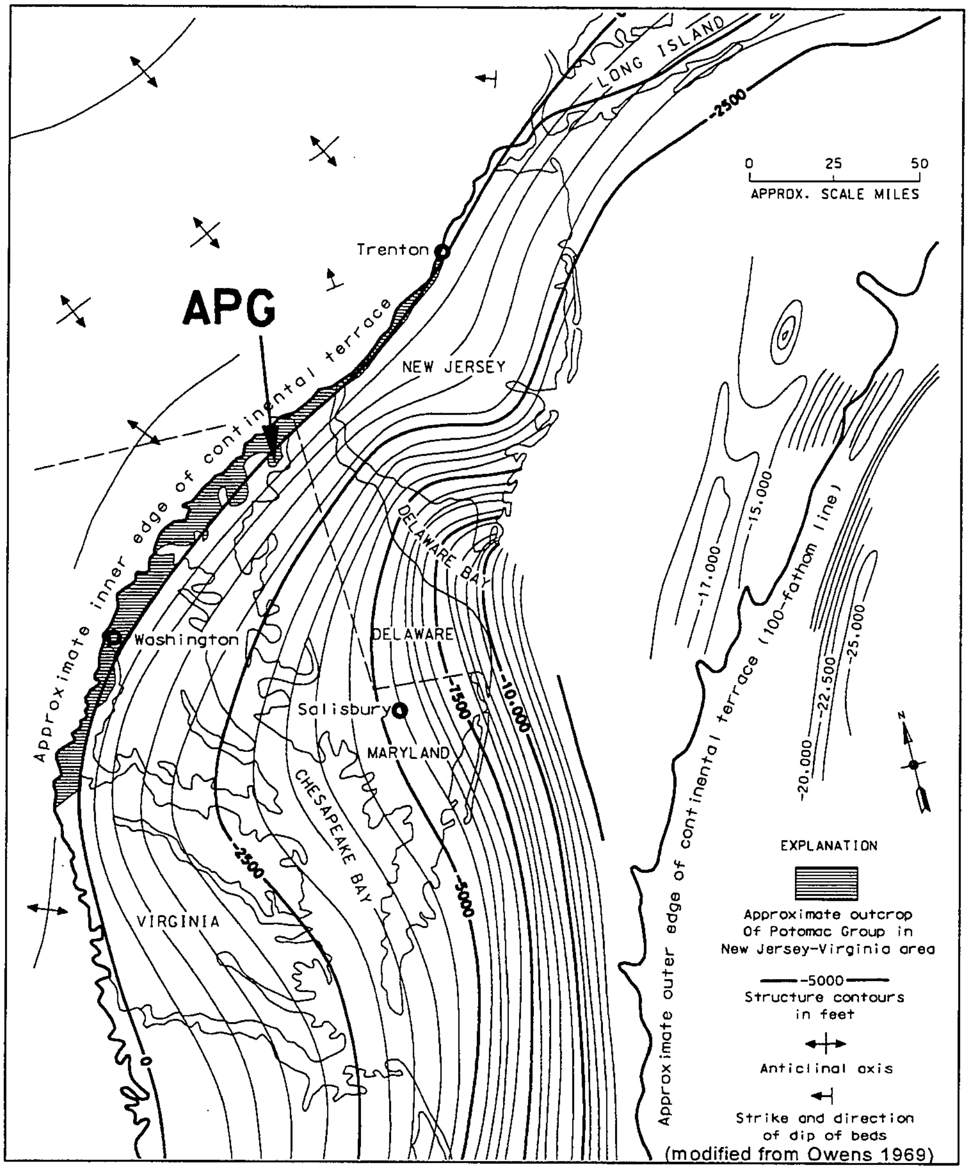


Figure 9. Surface of basement rocks beneath Coastal Plain

called the Salisbury Embayment and is one of the largest basement structures of its type beneath the Coastal Plain.

Transgressive and regressive seas during the Cretaceous age resulted in the deposition of layers of clay, silt, sand, and gravel. Later, glacially related transgressions and regressions further modified the geomorphology to form the present day Coastal Plain. The interbedded layers of unconsolidated sediments form a wedge that begins at the Fall Line and thickens to the southeast. Abundant muscovite and a varied suite of heavy minerals of metamorphic origin found in the sediments suggest the pelitic metamorphic rocks of the Piedmont were a major sediment source. From the absence of calcic plagioclase, hornblende, and pyroxene, it appears that little material, except in the form of silt and clay, was supplied to the Coastal Plain by the mafic rocks of the Piedmont (Owens 1969).

Sediments of the Coastal Plain in Maryland range in age from Cretaceous to Quaternary (Table 3). The dip of the formations to the south-southeast ranges from an average of 75 ft per mile (ft/mi) near the basement rock to 10 ft/mi for the upper Tertiary formations. These formations exhibit a gradual increase in thickness down dip from the Fall Line accompanied by a decrease in dip for successively younger formations. Along with the increase in thickness and decrease in dip, the sediments generally become finer to the east (Dames and Moore 1972).

TABLE 3
General Stratigraphic Units of the Coastal Plain in Maryland

SYSTEM	SERIES	STRATIGRAPHIC UNITS	
Quaternary	Holocene to Pliocene	Columbia Group undivided, and upland and lowland deposits (Otton 1955)	Talbot Formation
Tertiary	Miocene	Chesapeake Group	
	Eocene Paleocene	Pamunkey Group	
Cretaceous	Upper Cretaceous	Severn Formation (Minard, Sohl, and Owens 1977)	
		Matawan Formation	
		Magothy Formation	
		Potomac Group	Patapsco Formation
	Lower Cretaceous		Arundel Formation
			Patuxent Formation
Jurassic (?) to Precambrian		Basement Rocks	

(modified from Vroblesky and Fleck 1991)

The Potomac Group of the Early Cretaceous age, the Talbot Formation of the Pleistocene age , and the alluvium, swamp , and marsh deposits of the Holocene age are the only geologic units believed to be present in the area of APG-AA. There is a gap in the geologic record from the Late Cretaceous through the Late Tertiary in this area. The Late Cretaceous through Late Tertiary inter-bedded marine-continental sequences are widespread east of Chesapeake Bay, but do not crop out in Harford County, MD (Owens 1969).

Potomac Group

The Early Cretaceous sediments of the Potomac Group unconformably overlie the Precambrian basement rock. Various studies of the Cretaceous Potomac Group in Maryland and Delaware have been conducted. Glaser (1969)

and Owens (1969) summarize those stratigraphic studies up to 1969.

The group of sediments currently referred to as the Potomac Group were originally named the Potomac Formation by McGee (1888). Clark (1897) first introduced the idea of dividing the Potomac Group sediments into four formations, and later (Clark 1910), into three distinct formations, the Patapsco, Arundel, and Patuxent, near the outcrop. Table 3 illustrates the stratigraphic order of these three formations. Others, such as Doyle and Robbins (1977) and Jordan and Smith (1983), also have followed this practice. However, lateral and vertical variations in lithology and texture of the Potomac Group sediments have made it difficult to subdivide the Potomac on the basis of stratigraphy. The results of various studies show that individual sand or clay units cannot be confidently correlated over, even short distances (Vroblesky and Fleck 1991). Studies which discuss these difficulties include Spoljaric (1967), Jordan (1968 and 1983), Owens (1969) , and Hansen (1969).

Patuxent Formation

The Patuxent Formation is the basal unit of the Potomac Group and unconformably overlies the Precambrian basement rock. The thickness of this formation ranges from a thin belt that outcrops at the Fall Line to over 2,300 ft beneath Ocean City, MD. These sediments were the first to be deposited in up-dip areas of the Coastal Plain of Maryland, following the uplift of the Piedmont-Blue Ridge Province to the west during Early Cretaceous time (Glaser 1969).

It is believed that the nonmarine layers of sands, gravels, silts, and clays in the Patuxent Formation were produced by a complex of fluvial and deltaic sedimentation. The lithology of the Patuxent Formation includes white or light gray to orange-brown, moderately sorted, angular sands , and subrounded gravels. Gray to orange-brown silts and clays also occur and range from less than 25 percent to greater than 75 percent of the total formation (Hansen 1972). The formation consists of a complex series of channel and point-bar sands and gravels interstratified with floodplain silts and clays (Hansen 1972). Glaser (1969) compared characteristics of the basal Patuxent Formation, such as a coarse bimodal character associated with an abundance of plant fragments, scour and fill structures, clay-clast conglomerates, and lenticular bedding, to that of modern river channel sediments, such as the recent alluvial valley fill of the Mississippi River. The increase in clay content in the upper portions of the formation might indicate that a decrease in river gradients were responsible for the preservation of such features as channel fills, over-bank sediments, occasional carbonaceous swamp sediments (Glaser 1969), and possibly estuarine deposits (Groot 1955). The lack of sufficient data from the lower deltaic plain deposits makes it difficult to determine whether deposition was dominated by basinal or fluvial processes (Vroblesky and Fleck 1991).

The depositional environment described above produces rapid changes in lithology over short distances horizontally and vertically through time. Therefore, the Patuxent Formation exhibits little horizontal or vertical continuity. Such changes in the stratum allow the Patuxent Formation to be considered a multi-aquifer unit with several water-bearing sands. These water-

bearing sands range from irregularly bounded sheets to isolated sand bodies with varying thicknesses and permeabilities.

Listed below is a general synopsis of the Patuxent Formation:

Time period	Lower Cretaceous (97.5 to 144 million years ago (mya))
General description	Predominantly sands and gravels intercalated with silt lenses and multicolored clay lenses.
Depositional environment	A complex of fluvial and deltaic processes producing channel-fills, overbank deposits, occasional carbonaceous swamp sediments, and possibly estuarine deposits.
Mineralogy	Primary heavy mineral suite of staurolite-kyanite assemblage. Mature assemblages containing only very low to no percentages of amphiboles, pyroxene, feldspar, or semctite.
Palynology	Microfossil assemblages correlate to the Barremian and Aptian stages of the Early Cretaceous age. Indistinguishable from the Arundel assemblages, but lacks the angiosperms of the Patapsco Formation.

(unconformity between the Patapsco and the basement complex)

Arundel Formation

The Arundel Formation overlies the Patuxent Formation. The contact between the Arundel and the Patuxent is difficult to identify with certainty. The Arundel is predominantly a thick, dense, massive, variegated clay which appears to have been deposited in shallow, discontinuous swamp basins maintained by ponded drainage and a slow influx of sediment (Glaser 1969). Locally small concretionary masses of limonite-cemented ironstone are present. The clay of the Arundel often exhibits a network of slickensided-like fracture surfaces. This type of structure is common in flood basin deposits and is regarded by Allen (1965) and Grim and Allen (1938) to be a result of desiccation and consequent shrinkage prior to burial. There is an apparent lack of bedding in the Arundel clay facies. A possible explanation for this could be found in the effects of compaction as a result of a sediment being deposited in a loose hydrous condition (Schultz 1958).

The thick clay facies of the Arundel Formation is generally mappable in its type region in Southern Maryland. However, this clay unit has not been found to be continuous and mappable northeast of Baltimore County, MD (Edwards and Hansen 1979).

The interfingering of sand and clay becomes extensive a few miles down-dip of the type outcrop area, making it difficult to distinguish boundaries between aquifer and confining-bed units (Groot and Penny 1960; Jordon 1962, 1983). In these areas, the Arundel appears to be a zone of clay and sand units which separate two predominantly sandy zones in the Potomac Group as described by Sundstrom et al. (1967). This extensive interfingering of sand and clay units also creates difficulty in efforts to determine formation boundaries between the Patuxent and the Arundel. Examples of this strata are seen in logs in Edwards and Hansen (1979). It is possible that the depositional environment of this area of the Arundel Formation was very similar to that of the Patuxent Formation.

Despite statements in the geologic literature concerning the lack of lateral continuity of the Arundel Clay northeast of Baltimore County (Edwards and Hansen 1979), many investigations in the Coastal Plain of Harford County report its presence. This may be a case of misidentification of a localized clay unit or a clay unit which may not be chronologically equivalent to the Arundel Clay.

The Arundel Formation is generally considered a confining layer or aquiclude in the immediate vicinity of APG-AA. This confining characteristic permits development of artesian pressures in the underlying Patuxent Formation (Geraghty and Miller 1985). The interfingered sands and clays seen in the Arundel Formation down-dip of APG-AA produce multi-aquifer characteristics as found in the Patuxent Formation. Several water-bearing sands of varying thicknesses and permeabilities ranging from irregularly bounded sheets to isolated sand bodies are found in this area.

Listed below is a general synopsis of the Arundel Formation:

Time period	Lower Cretaceous (97.5 to 144 mya)
General description	Predominantly a massive, dense, red, and gray clay. This clay exhibits slickensided surfaces in broken core samples in most areas. Interfingering of sands and/or silts occurs in some areas. Locally, small concretionary masses of limonite-cemented ironstone are present.
Depositional environment	Shallow discontinuous swamp basins maintained by ponded drainage and a slow influx of sediments. Areas of interfingered sand units deposited by a complex of fluvial and deltaic sedimentation.
Mineralogy	Mature assemblages containing very low percentages of smectite, feldspar, etc.
Palynology	Microfossil assemblages correlate to the Barremian and Aptian stages of the Early Cretaceous. Indistinguishable from the

Patuxent assemblages, but lacks the angiosperms of the Patapsco Formation.

Patapsco Formation

The Patapsco Formation unconformably overlies the Arundel Formation. The outcrop of this formation generally parallels the Fall Line. The Patapsco ranges from a thin belt at the outcrop to several thousands of feet thick beneath Ocean City, Maryland.

Lithologically, the Patapsco Formation consists of interbedded variegated gray, brown, and red silts and clays. Also included are argillaceous, sub-rounded, fine- to medium-grained quartz sands with minor amounts of gravel. Sand ranges between 25 and 50 percent. In general, the Patapsco Formation is finer in texture than the Patuxent Formation.

The Patuxent Formation is thought to be the product of fluvial (river) and paludal (swamp) deposition. The depositional environment was that of a low coastal plain traversed by low-gradient meandering rivers. Other important features of this environment included broad flood basins and swampy inter-fluves. There are implications of lowered river gradients and a more subdued Piedmont topography in which chemical weathering was more complete than in the earlier Cretaceous time (Glaser 1969).

Like the Patuxent Formation, the Patapsco Formation is a multi-aquifer unit. Channel and point bar sands are relatively thick, irregularly bounded sheets that are generally good aquifers. Sands associated with the clay strata are discon-tinuous, isolated sand bodies which generally are not good aquifers (Hansen 1972; Geraghty and Miller 1985).

Listed below is a general synopsis of the Patapsco Formation:

Time period	Lower Cretaceous (97.5 to 144 mya).
General description	Fine to medium sand and silt intercalated with multicolored clay lenses.
Depositional environment	Low coastal plain traversed by low-gradient meandering rivers. Included broad floodplain basins and swampy interfluves.
Mineralogy	Heavy mineral assemblage primarily contains a zircon-tourmaline-rutile suite with epidote common in the area of the Eastern Shore of Maryland.
Palynology	Microfossil assemblages correlate to the Albian stage of the Early Cretaceous. An important characteristic is the presence of angiosperms

distinguishing the Patapsco from the underlying Arundel and Patuxent Formations.

(Unconformity between the Patapsco and Arundel Formations)

Pleistocene

Talbot Formation / Kent Island Formation

The Talbot Formation unconformably overlies the Potomac Group and is the formation at the surface over most of APG-AA. Owens (1969) noted that much of the Talbot Formation in Harford County lies within APG and was not available for study due to limited access and possible dangers associated with a military reserve. He estimated the thickness of the Talbot Formation to be between 40 and 60 ft. The Talbot Formation in Harford County was mapped earlier by Miller and Bibbins (1904) as the deposits whose upper surface lie at an altitude of 40 ft or below.

Owens (1969) describes the Talbot Formation as consisting of two litho-facies in Harford County. These are a lower, thick-bedded, gravelly sand facies with occasional clay beds and an upper, massive, very clayey silt or silty clay facies. The gravelly sand facies is overlain by the silty clay facies reguardless of altitude nearly everywhere in the area. Very large boulders, some as much as 6 ft across, occur in the gravelly sand facies. A study of the heavy minerals found in the gravelly sand facies revealed a generally immature compositional trend. Many of the less stable heavy minerals, such as epidote, hornblende, and magnetite, are common constituents in these beds (Owens 1969). The silt/clay facies in outcrop is typically tan to reddish brown near the surface and pale gray below. The gray clay exhibits thin reddish-orange oxidized zones extending along fractures. In less weathered zones along outcrops, the silt/clay is drab brown to dark gray. Similar minerals are found in the clay/silt facies and the clay beds of the gravelly sand facies. Montmorillonite is a major component of these clays. This would also be an indication of the relative chemical and mineralogical immaturity of the sediments in the Talbot Formation (Owens 1969).

Shattuck (1902) and Cooke (1952) considered the depositional environment of the Talbot to be marine. However, Owens (1969) says the depositional environment of the gravelly sand facies in Harford County has no marine characteristics and is clearly fluvial. He noted that the gravels were restricted to distinct channels and that the extensive trough cross-stratification seen in both sandy and gravelly beds was typical of channel fill (point-bar) deposits. He conjectured two possibilities for the depositional environment of the silty clay facies. The first possibility was that of over-bank deposits. He noted a similarity between the distribution of this silty clay facies in Harford County and the distribution of fine-grained litho-facies in the Brandywine area that were described by Hack (1955) as over-bank deposits. Hack (1955) had suggested a degrading stream as a mode of deposition because of the preservation of the litho-facies at progressively lower elevations (in a step-like manner). Owens conjectured, as a second possibility, that the silty clay facies might possibly be

estuarine or marine in origin, as are the deposits described by Bennett and Meyer (1952) at Sparrows Point east of Baltimore. The dark gray clay encountered at this location contained a basal gravel, with additional gravel lenses extending to a depth of approximately 115 ft from a 10 ft mean sea level (msl) ground surface elevation (el). The clay contained plant fragments, ostracods, *Ostrea* sp., and the pelecypod *Rangia cuneata* (Hack 1957). However, Owens discounted this correlation due to the thickness and depth at which the Sparrows Point clay-silt was found.

The Owens and Denny (1979) study of the Delmarva Peninsula (Delaware, Maryland, and Virginia) labeled deposits previously called the Talbot Formation in the lowland along the Chesapeake Bay as the Kent Island Formation. Data from recent drilling at APG-AA show a gray silty clay containing plant fragments and the pelecypod *Rangia cuneata.* If the Talbot Formation were considered as fluvial deposits (Owens 1969) and the Kent Island Formation as marine clays containing *Rangia cuneata,* both formations are present at APG-AA. The deposits of Bennett and Meyer (1952) at Sparrows Point may well correlate with these deposits.

Listed below is a general synopsis of the Talbot Formation / Kent Island Formation:

Time period	Pleistocene (10,000 to 2,000,000 years before present)
General description	Fine to medium silty sand with mixtures of coarse sands and gravel and lenses of silt and clay and localized areas containing a marine silty clay unit.
Depositional environment	Fluvial environment. Low coastal plain traversed by meandering rivers producing distinct areas of channel-fill and overbank deposits. Some areas included an estuarine environment with the presence of brackish water.
Mineralogy	Relatively young and compositionally immature assemblages with unstable components such as : a) amphiboles and pyroxenes in heavy mineral assemblages; b) smectite and/or feldspar in clay assemblages; c) field observation of the occasional presence of vivianite within the clay lithofacies.
Palynology	Microfossil assemblages correlate to the Pleistocene period and generally exhibit an abundance of pine, oak, and hickory, as well as herbaceous angiosperms and ferns.

Paleontology	Localized occurrences of the pelecypod *Rangia cuneata* (brackish water environment) observed within silty clay lithofacies. Abundant when found.

(Unconformity between the Talbot / Kent Island Formation and the Potomac Group)

Holocene

As a result of the latest rise in sea level, recent alluvium, swamp, and marsh deposits are found in the reaches of the rivers in those areas that were inundated. The composition of the alluvium ranges from clay to gravel, with the swamp and marsh deposits consisting of silts, clays, and organic matter. These surface sediments are heterogeneous and vary considerably laterally. Vertically, gravels are typically at the base with silts and clays dominating the upper portions. These sediments are limited in areal extent (Dames and Moore 1972).

The sands and gravels of the surface and subsurface sediments are permeable zones that conduct water. These permeable zones are often separated by low permeability/confining zones of silts and clays. The areal extent and thickness of both the permeable and the confining zones are variable. The overlying Talbot Formation and the underlying Patapsco Formation act as separate hydrologic units in some areas and as a single unit in other areas (ESE 1981).

Coastal Plain of Harford County

The southern third of Harford County, Maryland, is occupied by Coastal Plain sediments which overlap the rocks of the eastern Piedmont along the Fall Line. The Fall Line near the APG-AA study area lies to the northwest of APG-AA and roughly parallels U.S. Route 40 from Havre de Grace to Stepney where it then trends southwest to Interstate 95 near Riverside.

Coastal Plain sediments in Harford County are divided into three major units, the Potomac Group, the Talbot Formation, and Recent (Holocene) sediments. A generalized lithologic description of the Coastal Plain sediments in Harford County, Maryland, is shown in Table 4. Figure 10 is a geologic map of the APG-AA as mapped by Southwick and Owens (1968). The nature of the stratigraphic relationships between the Cretaceous and Pleistocene units in most up-dip areas is poorly understood as evidenced by conceptual diagrams presented by different workers in the area (Figures 11 and 12).

Previous investigations conducted on the APG-AA and adjacent areas have focused primarily on site characterization for environmental contamination concerns or development of groundwater supplies. Many of these studies are naturally influenced by the existing geologic literature concerning the Coastal Plain of Harford County. Approximately one-quarter of the county is underlain by Coastal Plain sediments and, of this, the majority is located within the boundary of APG. The greatest part of the Coastal Plain has not been studied in

TABLE 4 Generalized Lithology of the Coastal Plain in Harford Connty, MD					
System	**Series**	**Group**	**Formation**	**Generalized Lithology**	**Water-Bearing Properties**
Quaternary	Holocene (Recent)			Clay, sand, silt, and gravel	May yield large quantities of water where recharge can be induced from nearby streams
	Pleistocene		Talbot	Fine to medium silty sand with mixtures of fine gravel and lenses of silt and clay; localized areas of marine silty clay unit	Water table aquifer where composed of coarse grained water-bearing materials as in Aberdeen and Havre de Grace areas. Yields up to 500 gpm.
Cretaceous	Lower Cretaceous	Potomac	Patapsco	Fine to medium sand, silt, and clay	Yields some water to domestic wells in Harford County
			Arundel	Silty clay to clayey silt with lenses of organic silty clay and traces of lignite and ironstone nodules	Not a water-bearing formation except where penetrated by a few wells in outcrop area.
			Patuxent	Fine to medium sands and gravels intercalated with silt and clay lenses	Source of water for numerous domestic and small commercial groundwater supplies along U.S. Highway 40. Thickens rapidly toward southeast and becomes an excellent aquifer yielding up to 1,000 gpm.
Pre-Cambrian	Glenarm		Wissahickon and others	Bedrock	Not a water-bearing formation.

(modified from Bandoian and Waldrop 1985)

a regional context because of hazards associated with a functioning military reservation (Owens 1969).

Investigations On or Near APG-AA

The following sections are summaries of selected, relevant investigations on APG-AA and adjacent areas. Figure 13 shows where some of the investigations are on APG-AA. Many of the investigations invoked stratigraphic nomenclature to conform with previously published literature when attempting to discern individual geologic units. An effort has been made here by the authors to separate raw lithologic data generated by these investigations from

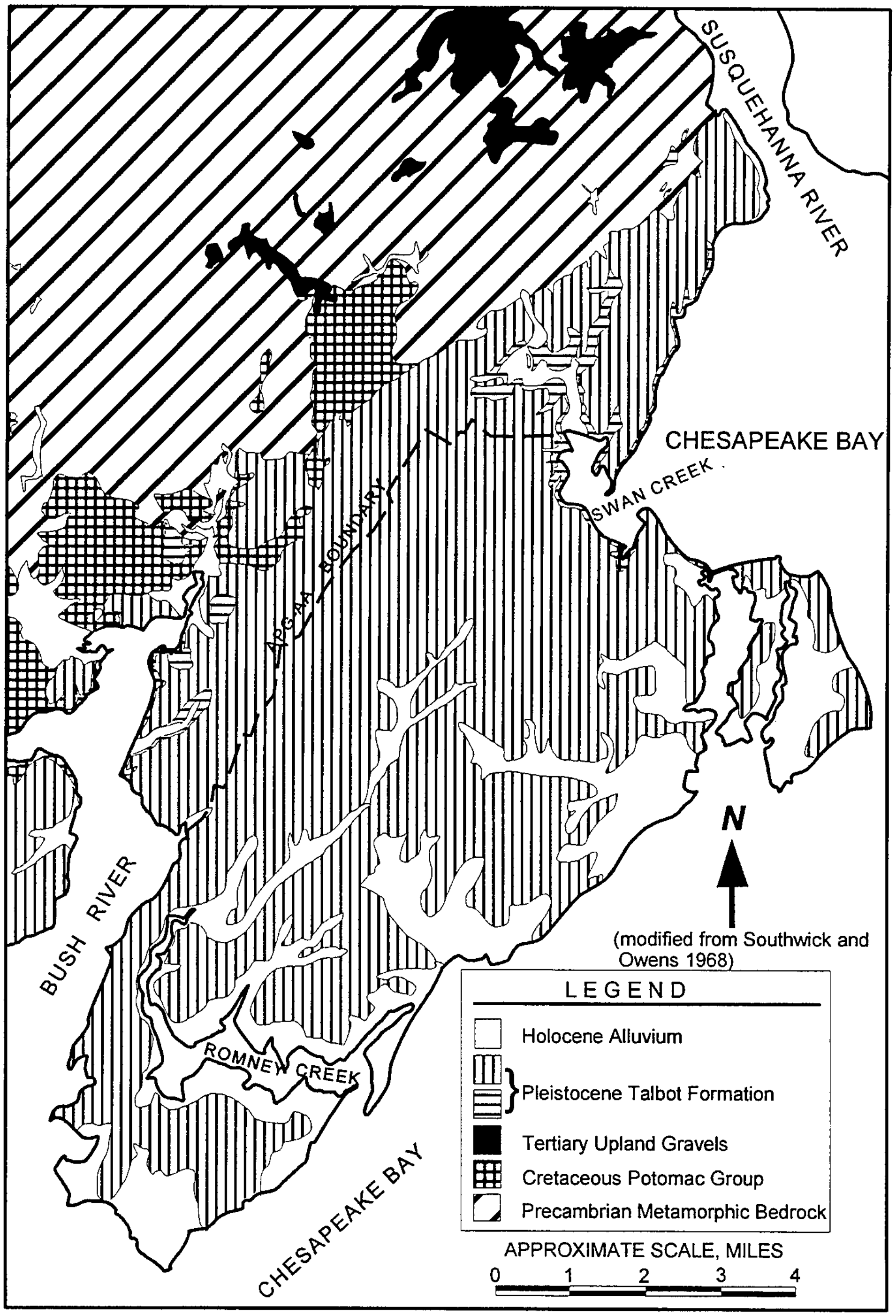


Figure 10. Geologic map of APG-AA

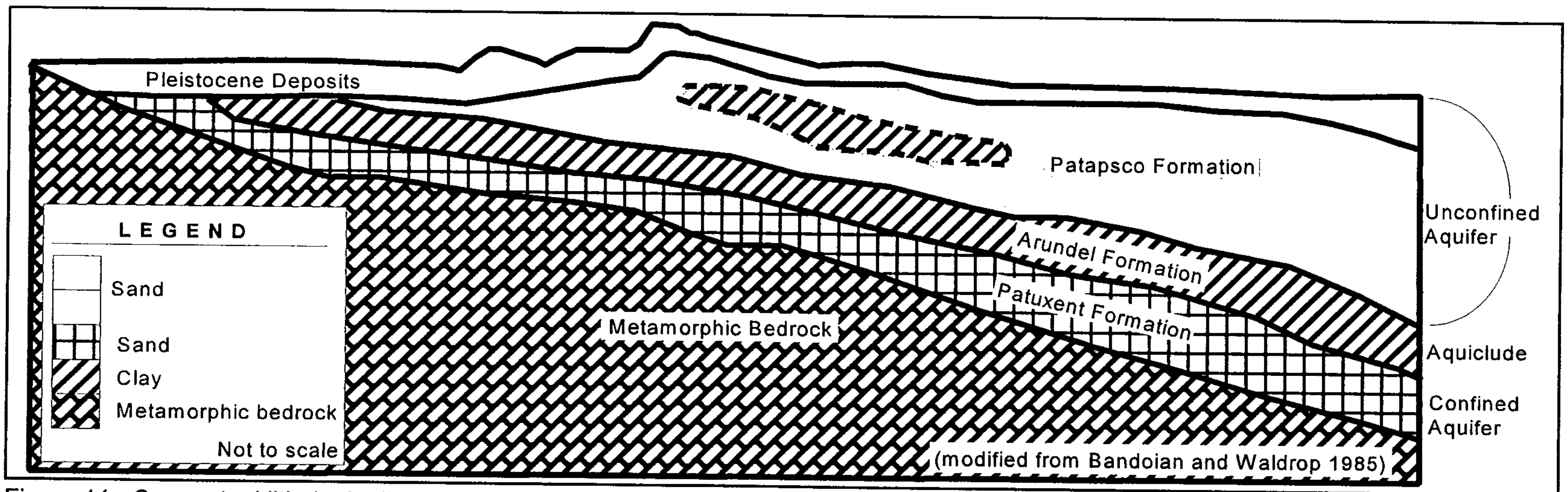


Figure 11. Conceptual lithologic diagram of Coastal Plain sediments in Harford County, Maryland

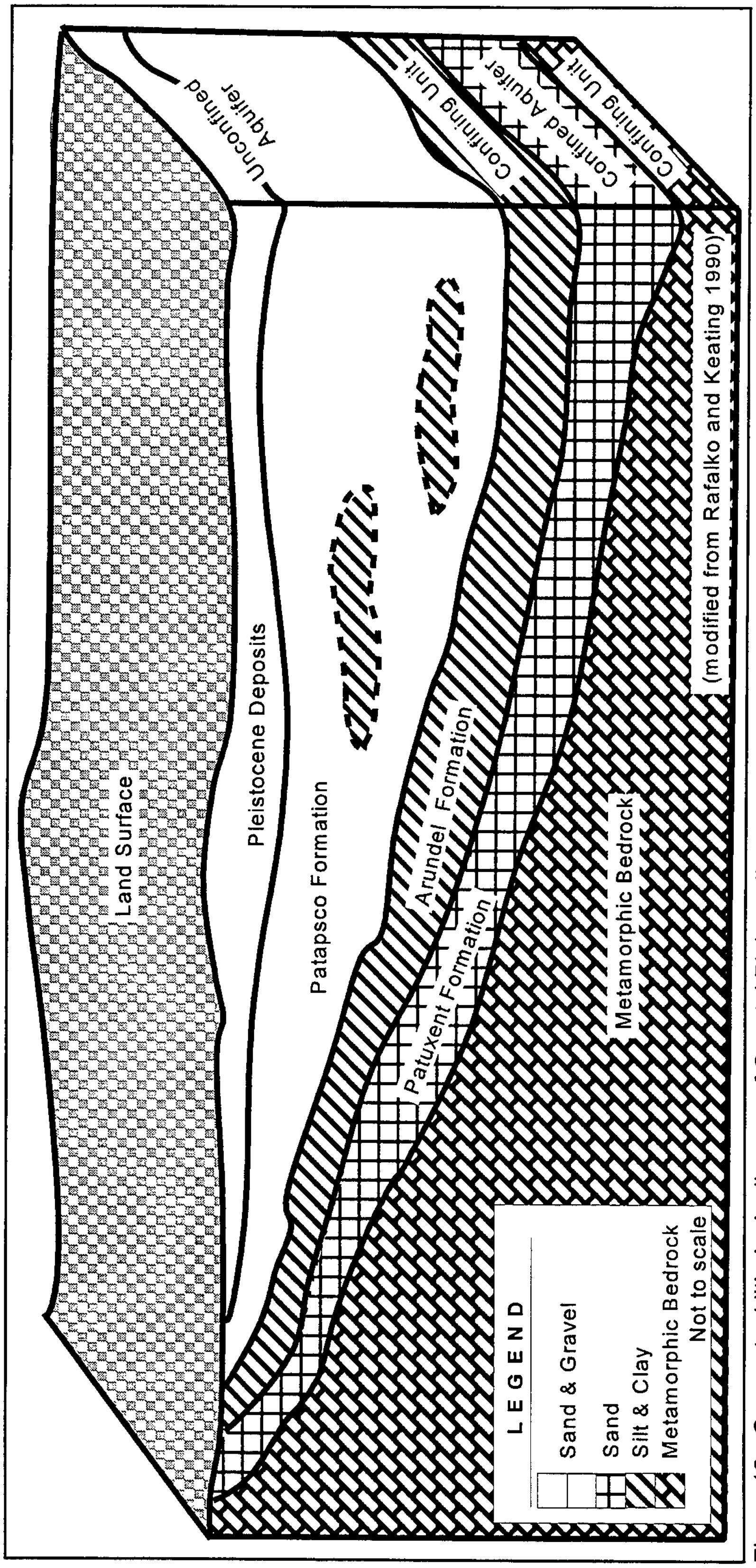


Figure 12. Conceptual lithologic diagram of Coastal Plain sediments in Harford County, Maryland

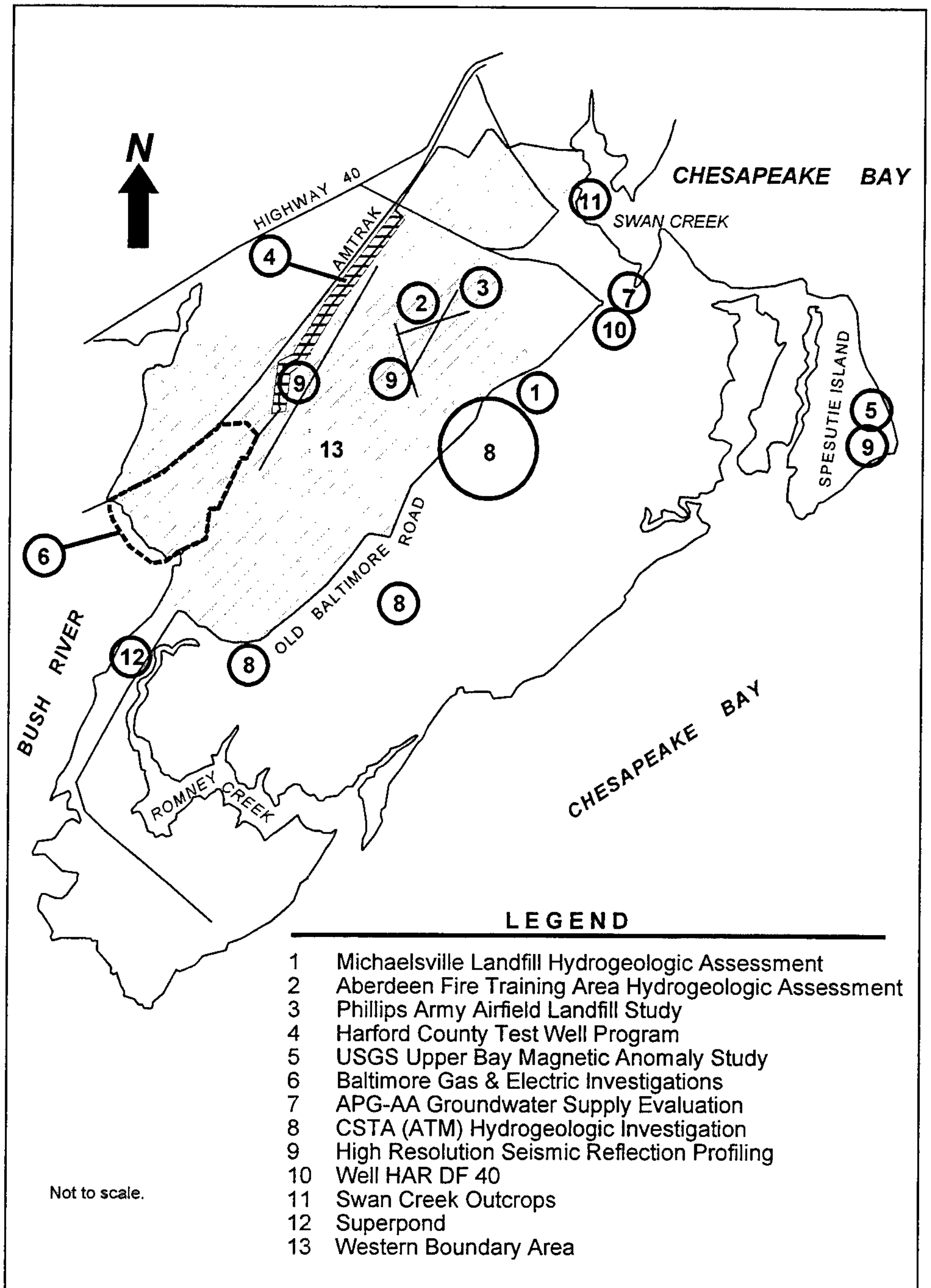


Figure 13. Location of previous investigations at APG-AA

preexisting stratigraphic relationships.

Michaelsville Landfill investigations

Michaelsville Landfill (MLF) is a National Priorities List site located in the approximate center of the northern portion of APG-AA (Figure 13). MLF has been the focus of several investigations. The two most comprehensive investigations, the Michaelsville Landfill Hydrogeologic Assessment

(Derryberry, Miller, and Breland 1990) and Michaelsville Landfill Operable Unit Two (Metcalf and Eddy (M&E) 1996), will be discussed here.

During the Michaelsville Landfill Hydrogeologic Assessment, 7 geotechnical borings and 25 groundwater monitor wells were installed to supplement 8 shallow monitor wells installed by the U. S. Army Engineer District, Baltimore (USAEDB) in 1980 (Figure 14). The deepest geotechnical boring, MLF-B3, was drilled to el -194.5 ft msl. The topography around MLF is generally flat with an average elevation of approximately 32 ft msl.

The Hydrogeologic Assessment report identified two aquifers in the upper 200 ft of shallow sediments beneath MLF. The uppermost aquifer is considered to be semiconfined. It is stated that the aquifer condition varies from water table to confined, depending on the amount of recharge. The upper aquifer consists of 20 to 30 ft of silts and sands with laterally discontinuous clay layers. An approximately 10-ft-thick silty clay layer overlying the upper aquifer on the eastern portion of the site functions as a confining unit. The shallow and intermediate depth monitoring wells from both investigations are finished in different zones of the upper aquifer.

Underlying the upper aquifer at an elevation of approximately -10 ft msl are 50 to 65 ft of interbedded clays, silts, and sands, which function as a semi-confining layer between the upper and lower aquifers. Two sand layers are present in this unit under the eastern portion of the site. These two sand layers may function as additional minor aquifers, but they are not discernable across the entire site.

The lower aquifer, which is penetrated by the deepest monitoring wells at the site, is located beneath the semiconfining unit. This aquifer consists of two lithologic zones, an upper zone composed of fine-grained sand from el -64 ft to -84 ft msl, and a lower zone of fine organic clay, silt, and very fine sand from el -84 ft to -94 ft msl. All of the deep monitoring wells are screened in the lower lithologic zone. There are no wells screened in upper portion of the lower aquifer. Groundwater elevation data indicate the hydraulic head in the lower aquifer is consistently 2 ft less than in the upper aquifer indicating potential recharge of the lower aquifer through the aquitard.

Four of the deepest geotechnical borings advanced at MLF encountered a hard, waxy clay which appeared to occur with lateral consistency across the site. Boring MLF-B3 encountered this clay at el -95 ft msl and was advanced to el -190 ft msl, where a gravel zone was encountered. The boring was terminated in the gravel zone at -194.5 msl. The hard waxy clay, which functions as the lower confining unit for the lower aquifer at MLF, was tentatively correlated with the Arundel Clay Formation of the Potomac Group. The correlation was based on strike and dip calculations and extrapolation from stratigraphic work conducted northeast of APG-AA by the USGS (Edwards and Hansen 1979).

The Michaelsville Landfill Operable Unit Two Investigation (M&E 1996) included six soil borings (borings MLF-B- 8 through -13), a set of three monitor wells (wells WES-M-26 through -43) installed at each borehole site, and five

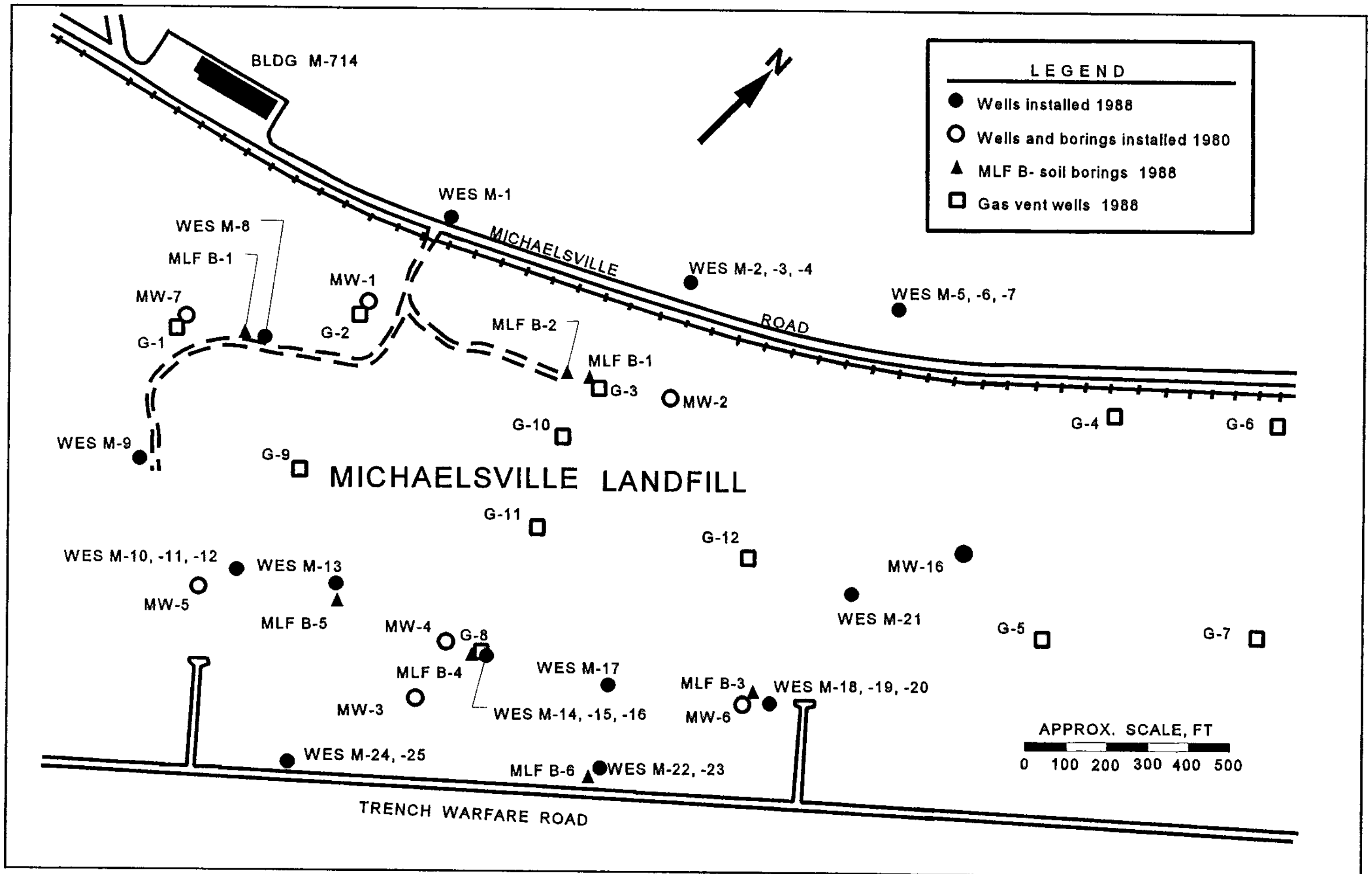


Figure 14. Location of monitoring wells, soil borings, and gas vent wells at Michaelsville Landfill prior to 1995

shallow piezometers (Figure 15). Each of the six soil borings were drilled into the lower clay underlying the second aquifer identified in the Derryberry, Miller, and Breland (1990) report. Boring MLF-B-13 was drilled through the lower clay into the gravels encountered by boring MLF-B-3. Figure 16 shows the four zones (upper silt and clay; upper sand and gravel; interbedded silt, clay, and sand; and lower clay) identified in the Derryberry, Miller, and Breland (1990) report. The sand and gravel zone shown in the bottom right corner of the figure was identified from boring MLF-B-3 and MLF-B-13. The six M&E borings ranged in depth from 141 to 181 ft. Lithologic data from geophysical logs and split spoon samples were used to determine the location of each of the three monitoring wells installed at each bore hole site. A well screen was placed at the water table, the base of the upper sand and gravel zone, and in the silty sand zone.

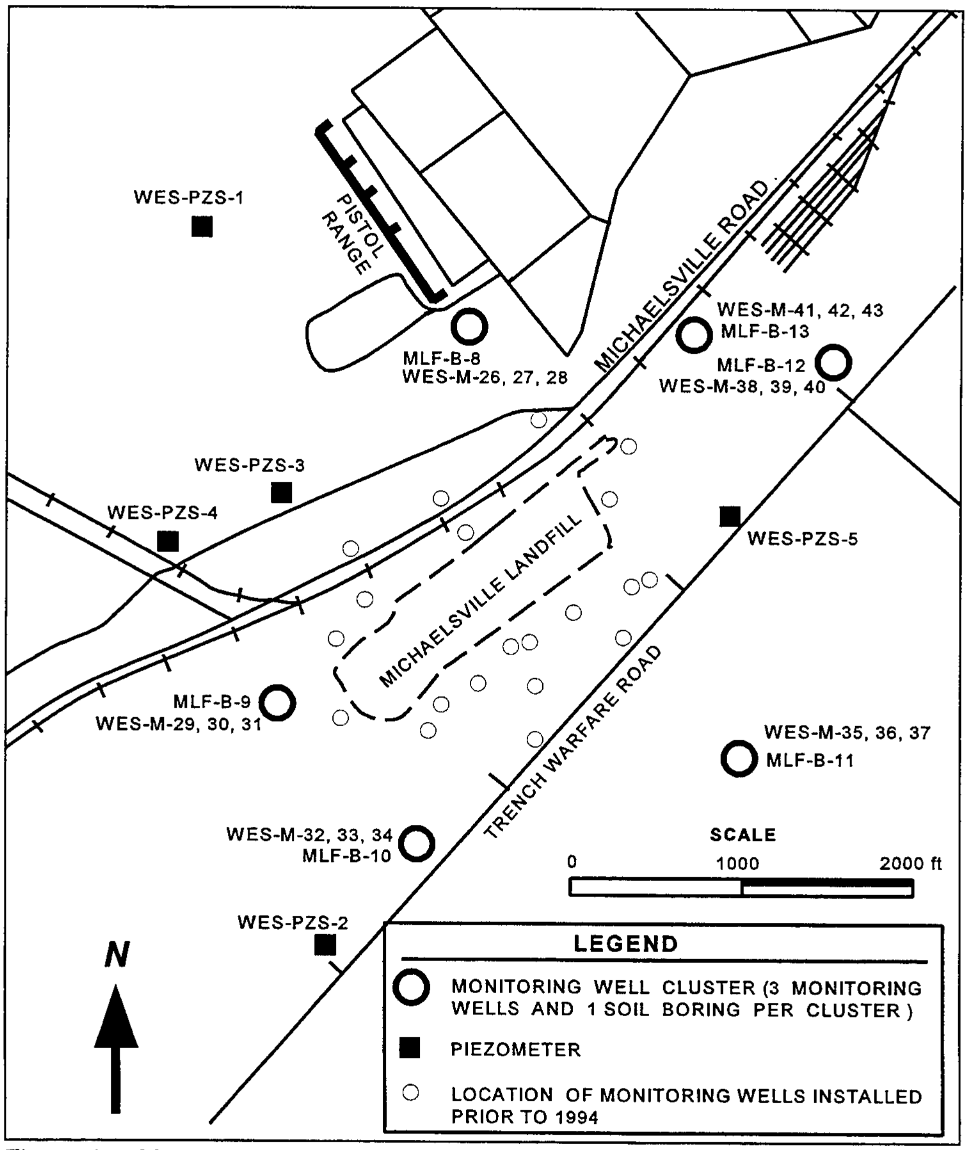


Figure 15. Monitoring wells and piezometers installed during MLF Operable Unit Two Investigation

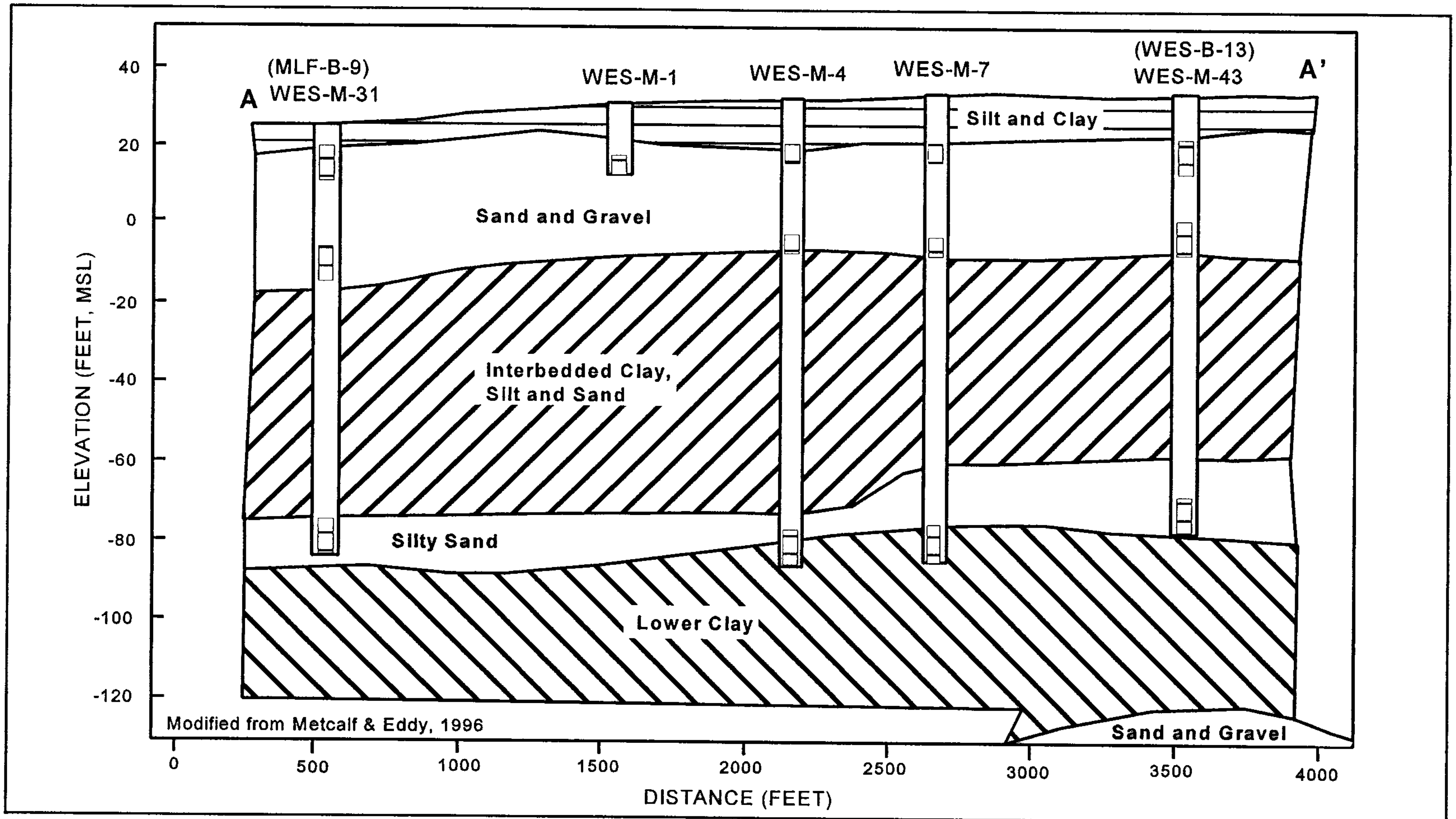


Figure 16. Cross section A-A' at MLF. Locations of the well screens in each well cluster are shown

Aberdeen Fire Training Area hydrogeologic assessment

The Aberdeen Fire Training Area (AFTA) is located north of, and adjacent to, the Phillips Army Airfield (PAAF) (Figure 17). Fire fighter training exercises were conducted at this site in the past. The approximate elevation of this site is 60 ft msl. A total of 12 monitoring wells and three geotechnical borings were installed during this investigation (Whitten et al. 1992). The deepest boring, FTA-SB2, was advanced to el -68 ft msl.

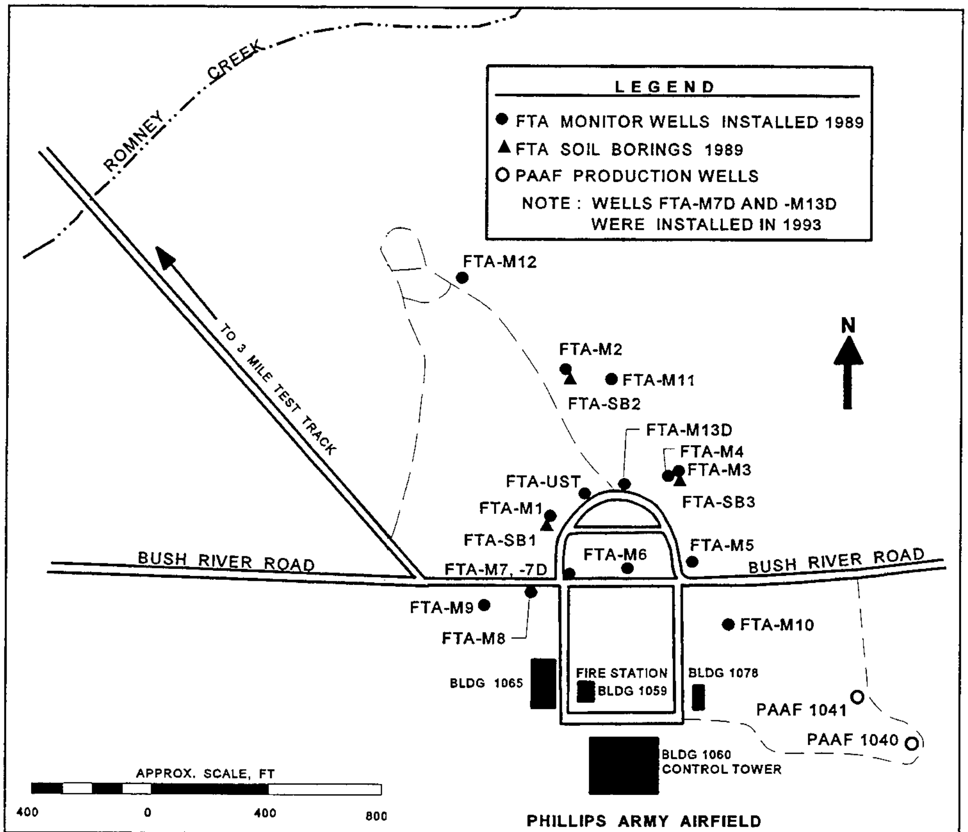


Figure 17. Location of groundwater monitor wells and soil borings at AFTA

The subsurface investigation at AFTA revealed three general litho-stratigraphic zones. The upper zone consists of a 7.5- to 11-ft-thick layer of sandy, clayey silt with traces of gravel. The intermediate lithologic unit under the site is composed of gravelly, silty sand ranging from 58 to 67.5 ft thick. This zone contains lenses of fine to coarse silty sand, with scattered traces of gravel and silt and clay lenses. Lenses within this intermediate zone could not be confidently correlated across the site with the available data. The lower lithologic unit consists of a stiff red clay of unknown thickness, underlying the gravelly silty sand. All three of the borings at the AFTA were terminated in a stiff red clay, which was first encountered at approximately el -13 to -16 ft msl. Boring FTA-B2 was advanced 53.5 ft into the clay unit. The AFTA investigation identified the clay unit as the Arundel Clay Formation of the Potomac Group based on its stratigraphic and structural relationship with the basal clay unit underlying MLF.

All of the monitoring wells installed during this study are screened at the water table. All of the screen settings for the original 12 wells are centered at approximately el 30 ft msl. Two deeper monitoring wells (FTA-M7D and -M13D) were installed during the Western Boundary investigation (General Physics Corp. (GP) 1993). The deeper wells were screened at the base of the sand and gravel unit, just above the basal clay unit. The elevation of the groundwater level in these two deep wells are similar to that in the previously existing water table wells indicating no significant difference in hydraulic head between the upper and lower zone of the aquifer at this location. Review of groundwater elevation measurements made in the spring of 1993 on two of the shallow AFTA wells and the two deep AFTA wells indicate similar groundwater elevations and similar seasonal elevation changes.

Phillips Army Airfield Landfill studies

Phillips Army Airfield Landfill (PAAFLF) is located northeast of PAAF, between PAAF and Boothby Hill Road (Figure 18). The average ground surface elevation is at the PAAFLF is approximately 55 ft msl, while the area immediately south of the PAAFLF is approximately 35 ft msl. The PAAFLF was in operation from 1950 until the mid-1980s. The site contains a sanitary landfill, refuse burning pits, grease pits, and borrow fill areas. Part of the site is being used today as a permitted disposal site for construction and demolition debris. Numerous studies were conducted at the PAAFLF from 1980 through 1992. The USAEDB conducted a hydrogeologic investigation of the PAAFLF in 1980 (USAEDB, 1980). Eleven shallow groundwater monitoring wells (PW-8 through -18) were installed and aquifer parameter tests were conducted. Wells PW-8 through -17 are screened at the top of the water table, which is approximately 25 ft msl. Well PW-18 is screened from approximately -15 to -30 ft msl. Boring data show the landfill appears to be in a transitional zone in that the sediments change from thicker sections of coarse sands and gravels in the north-northwestern portion of the site to clay with thin sections of finer silty sands and some traces of gravel to the south-southeast. The investigators speculated that the clay material may have been of estuarine origin and that the sands and gravels represented channel-fill deposits.

Wells AA-1 through -5 were installed by the USAEDB in 1980 between the PAAFLF and the City of Aberdeen production wells. Soil borings to a depth of 100 ft at each of the AA wells show 40 to 60 ft of sands and gravels overlying silts and clays.

The U.S. Army Environmental Hygiene Agency (USAEHA) installed three water table monitor wells (PW-19 through -21) in 1988 and conducted some aquifer tests (USAEHA 1988).

Drilling for the Phillips Army Airfield Groundwater Study Phase I Remedial Investigation (GP 1994) was completed in 1993. The project included the installation of three water table monitor wells (PW-22A, -23 and -24), one deep monitor well (PW-22B), 16 piezometers (PLP-1 through -16), and eight soil borings (SB-1 through -8). A fence diagram constructed from the soil borings

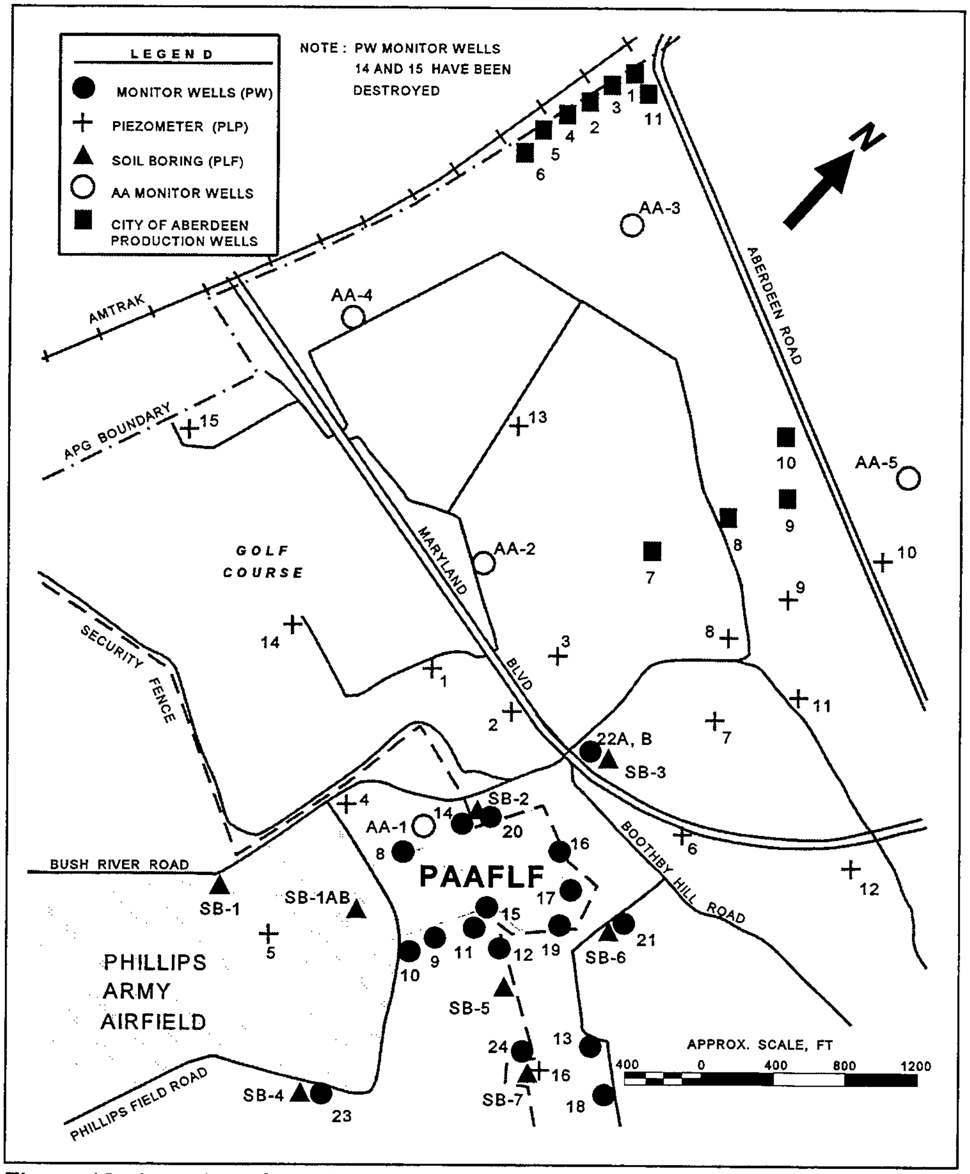


Figure 18. Location of monitor wells, piezometers, and soil borings at PAAFLF through 1993

show 40 to 60 ft of sands and gravel overlying a red and purple variegated clay in the northern portion of the PAAFLF, and 10 to 30 ft of silts and silty sands with scattered gravels overlying dark gray to brown clays and silts in the southern portion of the site (Figure 19). Lenses of sands and silty sands and lignitic materials are scattered throughout the dark gray to brown clays and silts .

Harford County Test Well Program

A substantial portion of raw water produced for the Harford County Department of Public Works is obtained from the Coastal Plain sediments in the vicinity of Perryman, MD. The county has conducted several investigations in this area. The 1976 Whitman, Requardt, and Associates investigation was the most comprehensive of the investigations (Figure 20). The report contains a geologic cross section paralleling the western boundary of APG-AA. This study

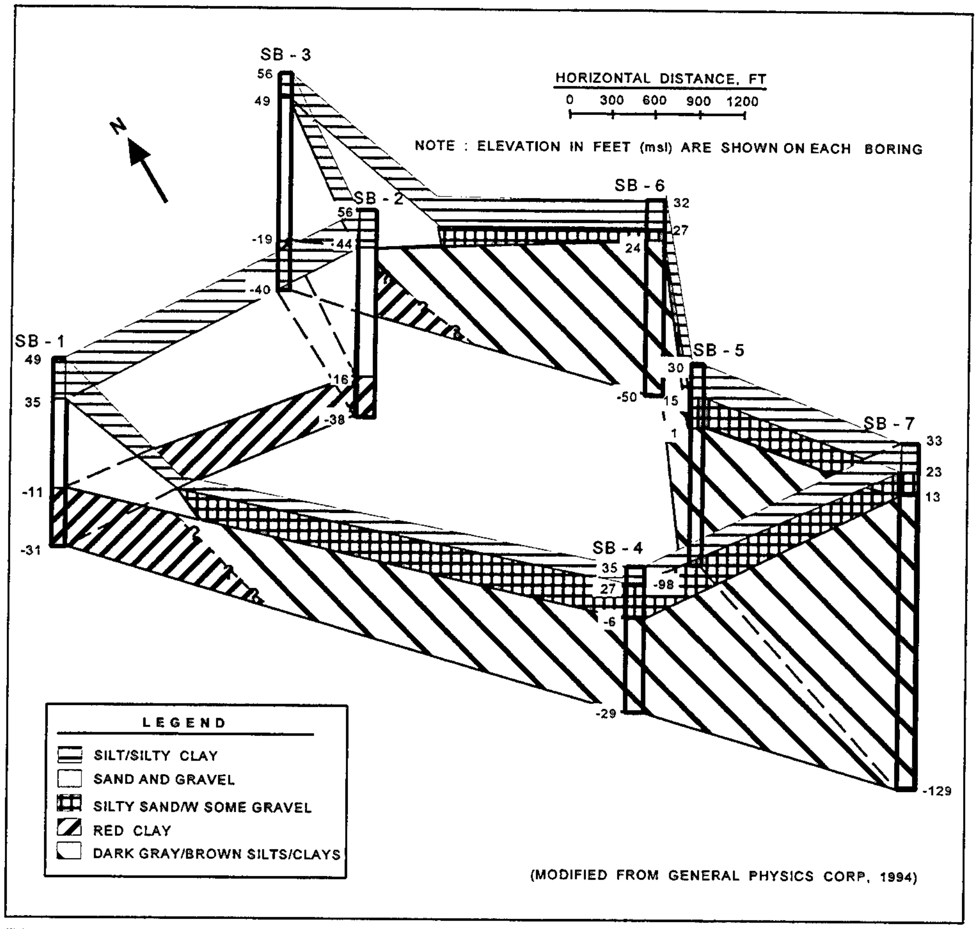


Figure 19. Fence diagram of PAAFLF area

adjoins the area that was later studied as the APG-AA Fire Training Area/Western Boundary Investigation. The average elevation in this area is approximately 40 ft msl.

The intent of the investigation was to make a determination of the availability of well water for public supply purposes in the Perryman area by means of a safe yield calculation for the existing well field. The Coastal Plain sediments overlying the crystalline bedrock generally ranged from 200 to 250 ft in thickness . It was noted that bedrock was encountered at el -287 ft msl in test well 2-76, whereas decomposed bedrock was detected at el -165 ft msl in a another test well located 2,000 ft to the northeast along strike.

The Whitman, Requardt and Associates (1976) report portrayed the Coastal Plain geology in litho-stratigraphic units, broken down as Pleistocene or Cretaceous sands. The focus of the report was on water-producing sands with very little discussion of semiconfining or confining units. This emphasis contrasts sharply with the emphasis on "barrier to groundwater flow" of many of the environmental contamination studies in the area. The cross section provided in the report indicated that sands identified as Pleistocene occur from ground surface to approximate el -10 ft msl in the northeastern portion of the study area and extend intermittently to approximate el -45 ft msl beneath Perryman. Sand

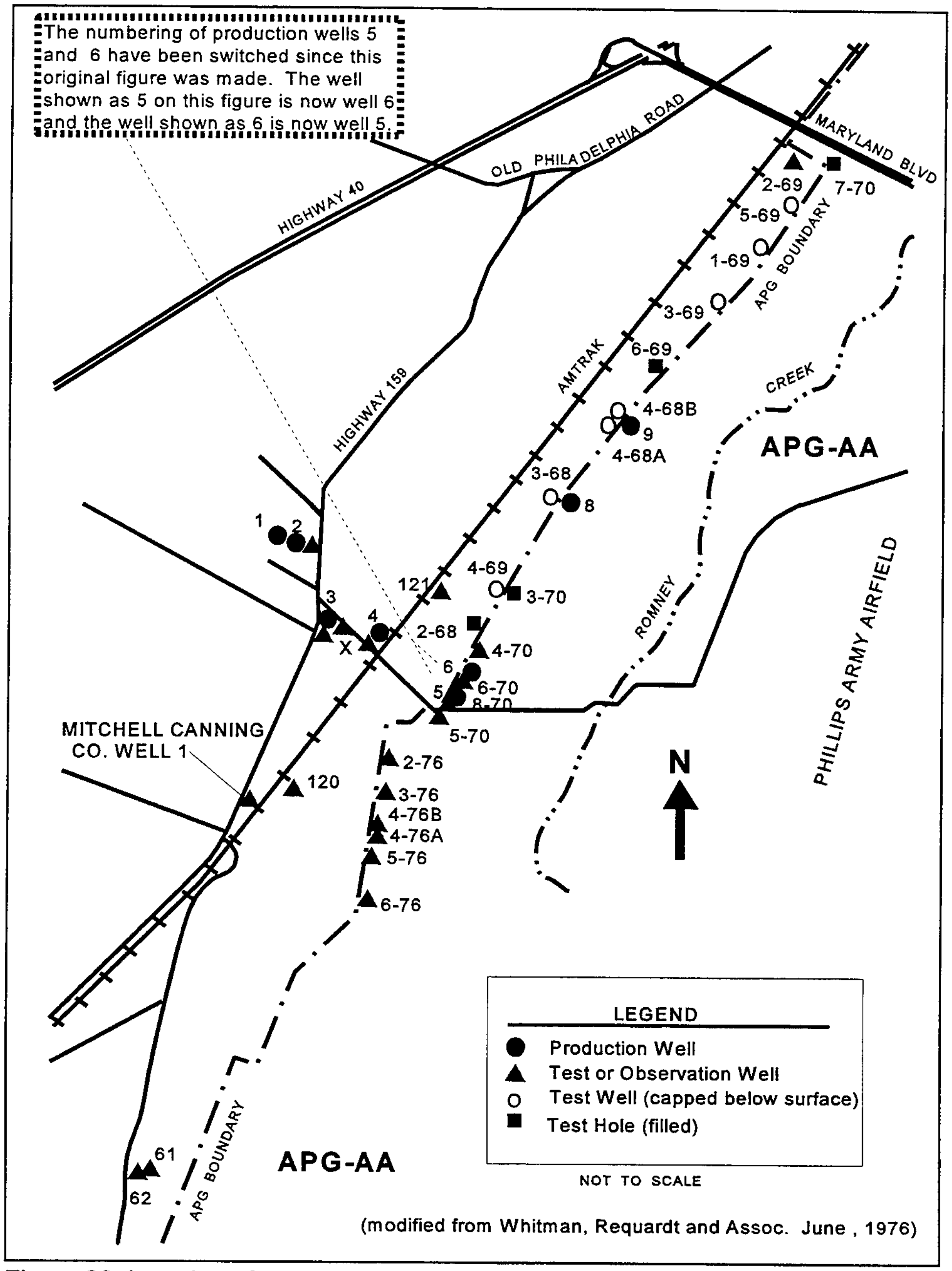


Figure 20. Location of wells and borings for the Harford County Test Well Program

units identified as Cretaceous in age are depicted in wells located in and southwest of Perryman. The upper elevation of these sands is -50 ft msl beneath Perryman to approximately -80 ft msl southwest of Perryman. Pleistocene and Cretaceous sands are in direct contact under Perryman. The sands identified as Cretaceous are present less frequently in wells located northeast of Perryman and are in fact reported to be absent in many of the wells. The increased depth and apparent increased frequency of the Cretaceous sands corresponds with decreasing elevation of the crystalline bedrock southwest of Perryman. The occurrence of the sands identified as Pleistocene do not reflect a similar pattern.

A noteworthy point in this report is the identification of the high-yielding zone beneath Perryman as a channel-fill feature. This channel-fill feature has subsequently been identified as a Quaternary terrace, which is discussed later in this report . The contact between the two sands is approximately at el -50 ft msl.

U.S. Geological Survey investigations

The USGS conducted a hydrogeologic investigation in 1984 which encompassed the Upper Chesapeake Bay from the Fall Line to the middle of the Delmarva Peninsula (Otton and Mandle 1984). The focus of the study was on the aquifers within the Potomac Group sediments. APG-AA is located at the western, up-dip edge of the study area. The investigation, which was regional in nature, did not break the Potomac group into hydrostratigraphic units. Thus, comparison with stratigraphy beneath APG-AA is not possible. The generalized groundwater flow system presented indicates that recharge to the Potomac Group is from infiltration of precipitation at its outcrop area near the Fall Line and through a very slow downward flow from overlying units. Groundwater discharge for all but perhaps the deepest aquifers in the Potomac Group is to the Chesapeake Bay and its tributaries. Evidence for this condition is based on the fact that the deepest aquifers have positive head values. Well Ha Df 40, which is located approximately 4,000 ft northeast of MLF, is screened at the base of the Coastal Plain sediments on APG-AA and has head values consistent with findings of the study. The fact that the head potential is very low, approximately 4 ft in the case of Ha Df 40, indicates the movement of groundwater vertically through the Potomac Group must be very slow (Otton and Mandle 1984).

Baltimore Gas & Electric investigations

Several hydrogeologic studies have been conducted on the Baltimore Gas & Electric (BG&E) property located between APG-AA and the Amtrack railroad corridor on the Bush River (Figure 21). A report entitled "Perryman Groundwater Report" (Rafalko and Keating 1990) serves as a compilation of the previous studies conducted at the site. The average elevation of the site ranges from approximately mean sea level at the Bush River to approximately 35 ft msl at the northeastern portion of the site. The hydrostratigraphy of the site is presented as an upper aquifer, clay unit, and lower aquifer which are equated with the Talbot/Patapsco Formations, Arundel Formation, and Patuxent Formation, respectively.

The upper aquifer is a water table aquifer containing discontinuous fine grained units which may serve locally as semiconfining units. One semiconfining unit was correlated over portions of the study area. The upper aquifer is depicted in cross section as extending from ground surface to an elevation ranging from -25 ft msl to -50 ft msl. The aquifer increases in thickness toward the south-southeast away from the Fall Zone. Frequently the contact of the base of the upper aquifer and the top of the underlying clay unit consists of a coarse sand and gravel layer greater than 10 ft in thickness at some locations. The semiconfining unit encompassed by this aquifer is absent in a zone extending through the middle of the site from the northwest to the

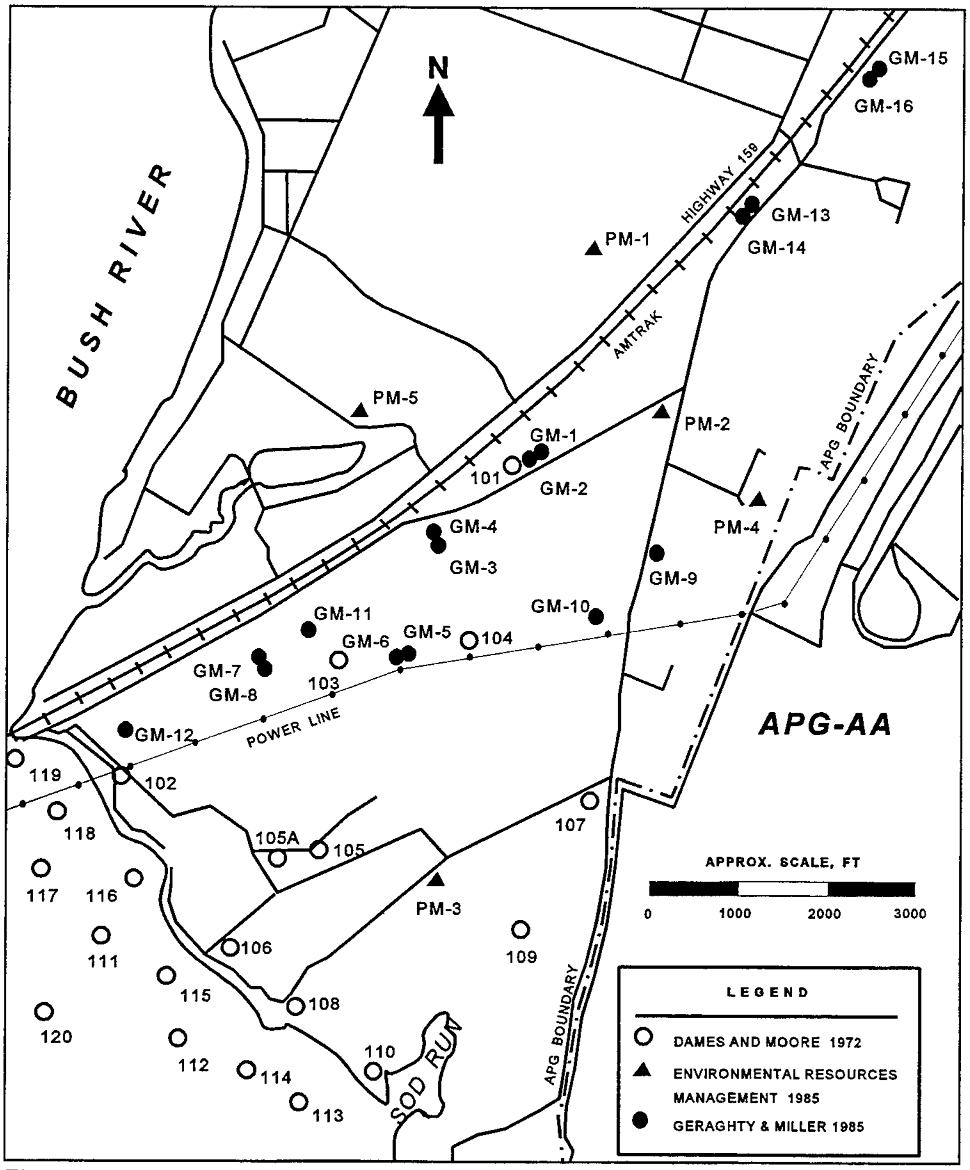


Figure 21. Location of borings, monitor wells, and piezometers from previous BG&E investigations at Perryman Site

southeast. The semiconfining unit then thickens to approximately 35 ft northeast and southwest of the center of the site. There are no data given concerning the attitude of the strata.

Separating the upper and lower aquifers is a clay unit identified as the Arundel clay in the report. The elevation of the top of the clay unit ranges from -25 to -99 ft msl. The higher elevations appear to follow a linear trend northeast to southwest through the center of the site while the lower elevations appear to skirt the topographic high. The resulting subsurface geomorphology of the top of this clay unit is similar to the geomorphology of the current land surface with respect to the current surface water drainage patterns (Figure 22). The thickness of the clay unit is much less in the southeastern portion of the site (15 to 40 ft) than the northwestern portion. Much like the surface topography of this unit, the greatest thickness tends to correspond with the higher surface elevation of the

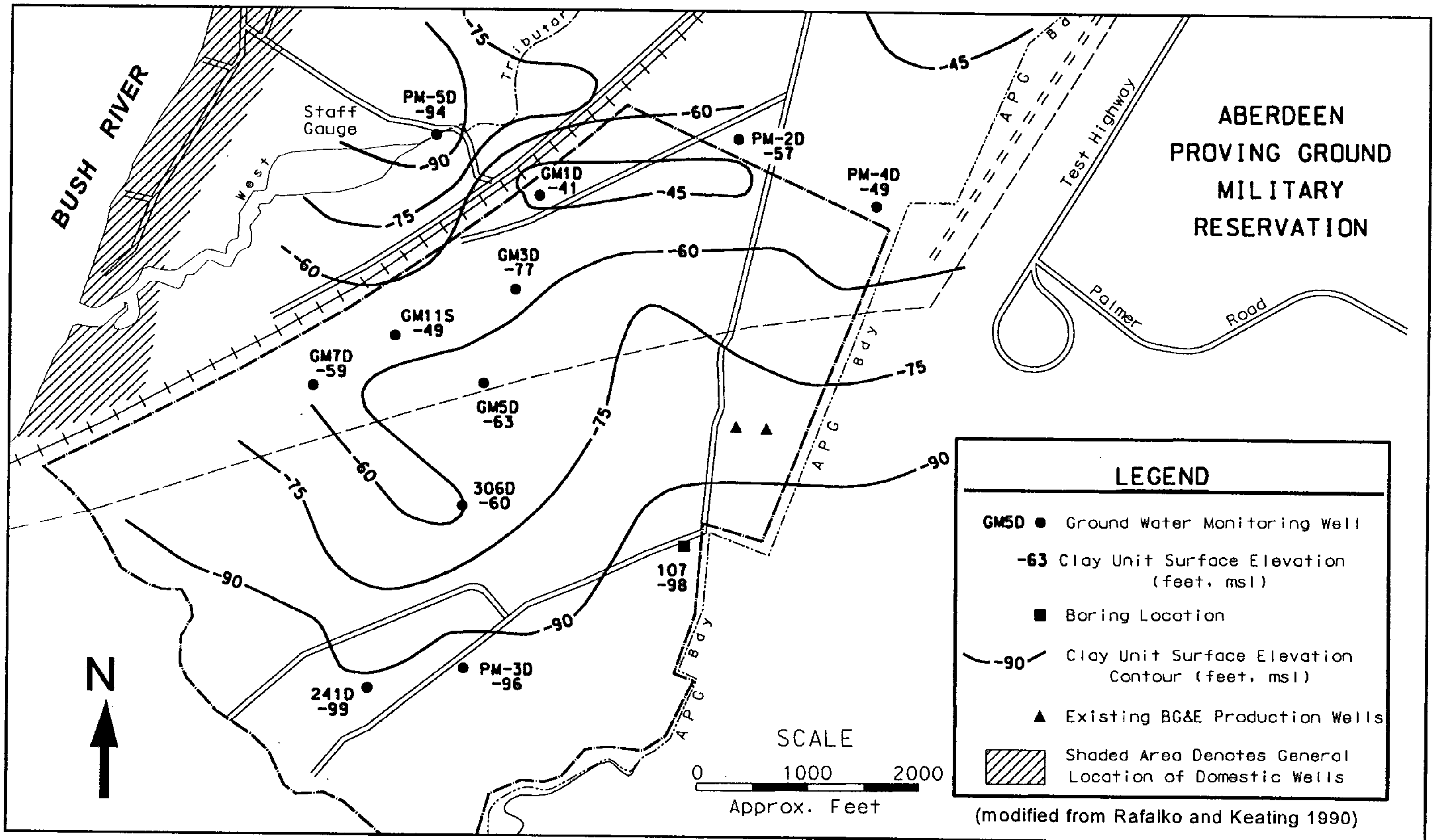


Figure 22. Contour map of clay unit top surface

unit. A single data point, with a substantially greater thickness, located in the northern portion of the study area contradicts this trend. The base of the clay unit is poorly defined, being gradational in nature, with the lower aquifer.

The lower confined aquifer, composed of silty sand and sand, is believed to be the Patuxent Formation. The top of the lower aquifer is reported to occur at elevations ranging from -80 ft msl to -220 ft msl, and is bounded above by the clay unit and below by saprolite and bedrock. The lower aquifer ranges in thickness from 90 to 160 ft.

APG-AA groundwater supply evaluation

A study (Moorshead-Siddiqui and Associates, Inc. 1983) was conducted to assess the supply potential of the existing APG-AA standby well field and two existing wells PAAF 1 (B1040) and PAAF 2 (B1041). The location of wells PAAF1 and -2 are shown on Figure 17. The APG-AA stand-by well field is located in a small stream valley, which drains into Swan Creek near Plum Point. The ground surface elevation in the well field ranges from 8 ft msl to 28 ft msl. The general elevation of the land surface surrounding the stream valley is approximately 35 ft msl.

This investigation concluded that the APG-AA standby well field consists of an unconfined upper aquifer and a lower confined aquifer with the probable existence of additional confined aquifers at depths in excess -182 ft msl. A preliminary examination of the drillers logs from the well field indicate that the top of the intervening confining clay unit occurs at approximately -31ft msl and terminates vertically at approximately -116 ft msl. The wells here are screened predominantly in the confined aquifer but some are screened in both. In three of the logs where the wells are screened in the lowest portion of the confined aquifer, a hard, red, gravelly clay is noted. This unit is likely to be the top of an intermediate confining unit, which functions as the base of the confined aquifer from which the APG-AA standby wells produce. The elevation of the top of this unit is approximately -135 ft msl.

CSTA (ATC) hydrogeologic investigation

The U. S. Army Combat Systems Test Activity (CSTA)(name changed to Aberdeen Test Center (ATC) in 1995) conducted a hydrogeologic investigation of several areas in APG-AA range area (Figure 23) (USAEDB 1990). The investigation included the installation of 24 shallow monitor wells and four soil borings in a relatively flat area where the elevation varied between 15 and 30 ft msl. All of the wells were screened at the water table. The bottom of the screens varied between 13 and 25 ft below ground surface.

The four soil borings were drilled to a depth of 205 ft (T-3 and T-4) or 215 ft (T-1 and T-2). Lithodensity, neutron, natural gamma, and caliper geophysical borehole logs were performed on all four borings. The geophysical logs from the four soil borings were used to identify aquifer zones and aquicludes (Figure 24). The investigation identified the general site geology, in descending order, as :

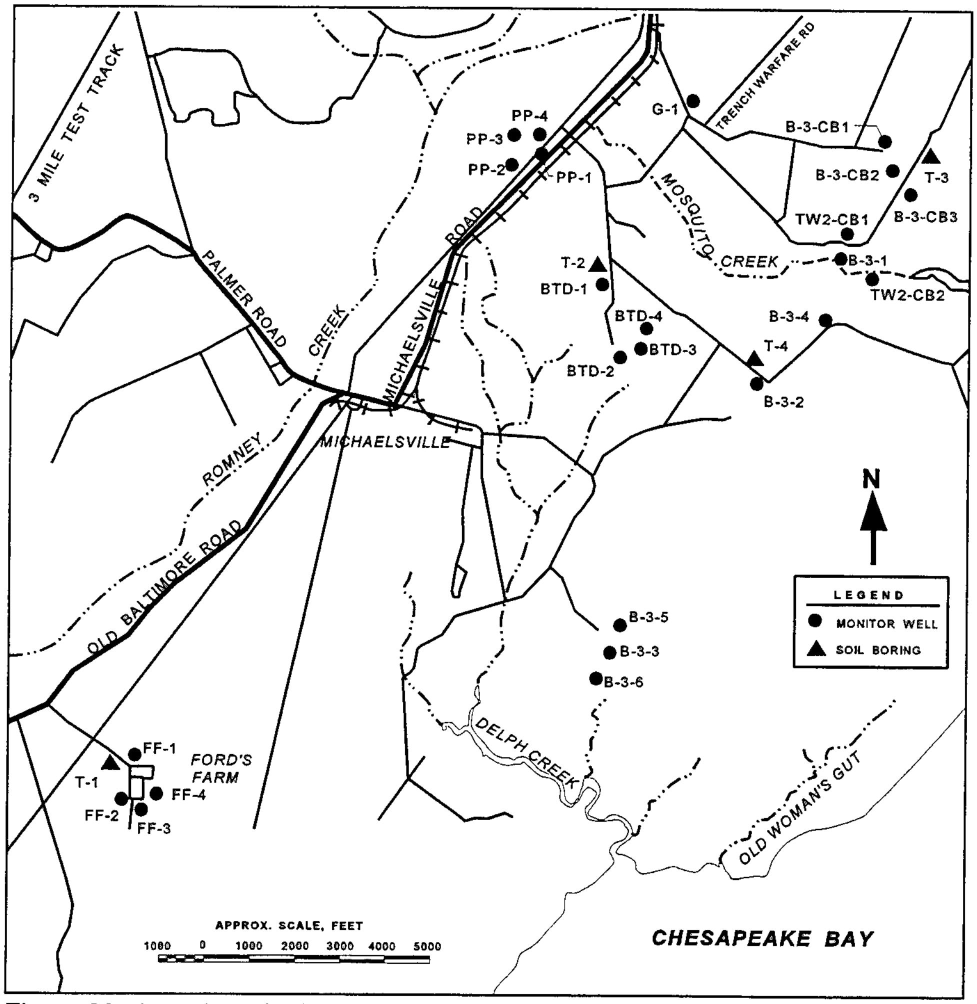


Figure 23. Location of CSTA (ATC) hydrogeologic investigation soil borings and monitor wells

a. Surface and near-surface soils consisting of relatively impervious fine-grained clayey silty sands.

b. An upper aquifer, approximately 40 to 70 ft thick, consisting of silty sand and occasional gravels with scattered, discontinuous impervious lenses.

c. An impervious clay aquiclude approximately 50 to 70 ft thick.

d. A lower silty sand and gravel aquifer approximately 25 to 60 ft thick.

e. A lower silt-clay aquiclude approximately 65 ft thick at boring T-2. The other borings ended in this silty clay.

f. Boring T-2 ended after drilling through approximately 13 ft of silty sands below the lower aquiclude.

The report stated the interdeltaic depositional environment in which the material was deposited varied substantially in its aerial extent, resulting in logs which are not easily correlatable.

Investigations in Upper Chesapeake Bay

Geologic data within the uppermost portion of Chesapeake Bay, adjacent to

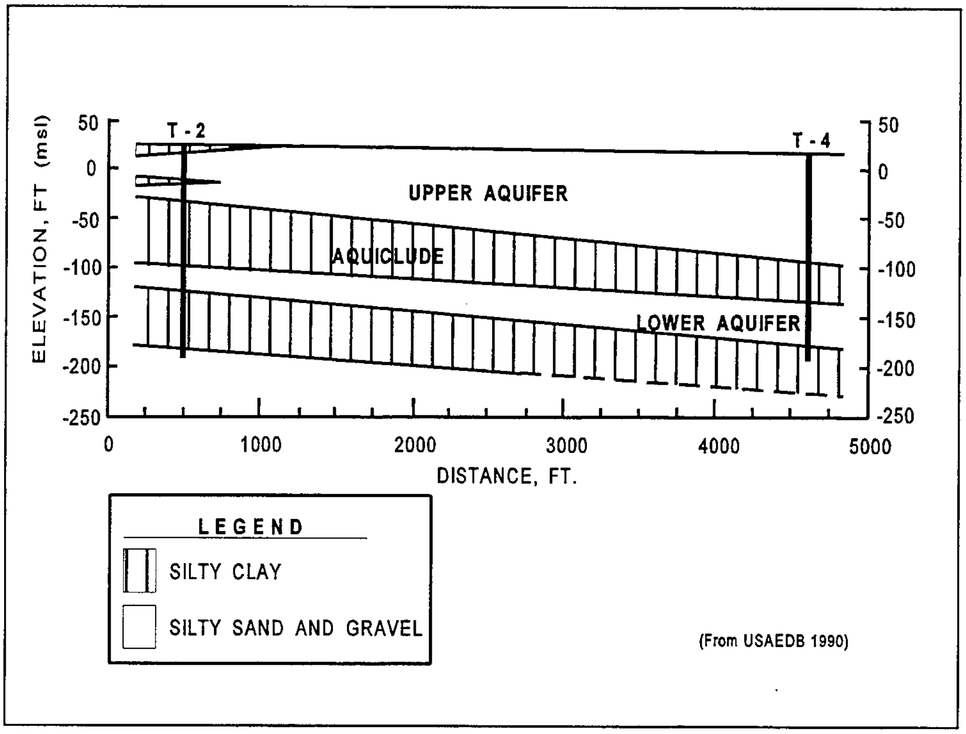


Figure 24. Generalized cross section from the CSTA (ATC) investigation

APG-AA, are limited. Two studies are discussed here which delineate the ancestral drainage system of the Chesapeake Bay. The first is a review and analysis of selected geotechnical borings conducted for construction of bridges across the Chesapeake Bay and its tributaries (Hack 1957). The primary characteristics by which correlation was drawn in this report were color, texture, and resistance to penetration. The latter parameter is defined by blow counts. The second study consisted of seismic surveys to identify ancestral Susquehanna River channels in the lower reaches of the bay (Colman and Halka 1989).

Borings for the construction of the U.S. Route 40 bridge at Havre de Grace were drilled at the upper end of the Chesapeake Bay where the Susquehanna River empties into the present bay. The bridge is located within the transitional zone of the Fall Line (U.S. Department of Agriculture (USDA) 1927). Borings indicate that the lowest elevation attained by down-cutting of the river into crystalline bedrock is -140 ft msl. The only other crossing which spanned the entire bay at that time was the Bay Bridge at Annapolis, MD, approximately 48 miles downstream of the U.S. Route 40 crossing. The lowest elevation of down-cutting into Eocene and Cretaceous age sediments is -200 ft msl. These data may be used to project the elevation of the ancestral channel beneath the bay based on an assumption of constant gradient. This results in an anticipated altitude of the base of the ancestral channel of el -150 ft msl adjacent to Spesutie Island and el -165 ft msl adjacent to Abbey Point.

Review of similar down-cutting data from crossings of tributaries to the main channel of the bay reveal a pattern of rapidly increasing gradient in the channels prior to their confluence with the main channel of the ancestral Susquehanna River. The author attributed this pattern to a response by the drainage network

to an episodic decrease in relative sea level. Such a change would cause increased flow velocity at the mouth of the system resulting in headward erosion of the underlying unconsolidated sediments.

Later seismic survey work conducted within the lower reaches of the bay reveal ancestral channel features at elevations consistent with what would be expected from review of the borings. Three separate ancestral channels of Quaternary age are defined for the lower portion of the bay, but they have not been identified in the upper reaches in the vicinity of APG-AA (Colman and Halka 1989).

From a review of bay and river boring logs Hack concludes the existence of an apparent litho-stratigraphic pattern within the channel fill deposits of the upper bay (Figure 25). In this investigation the lithology was divided into four

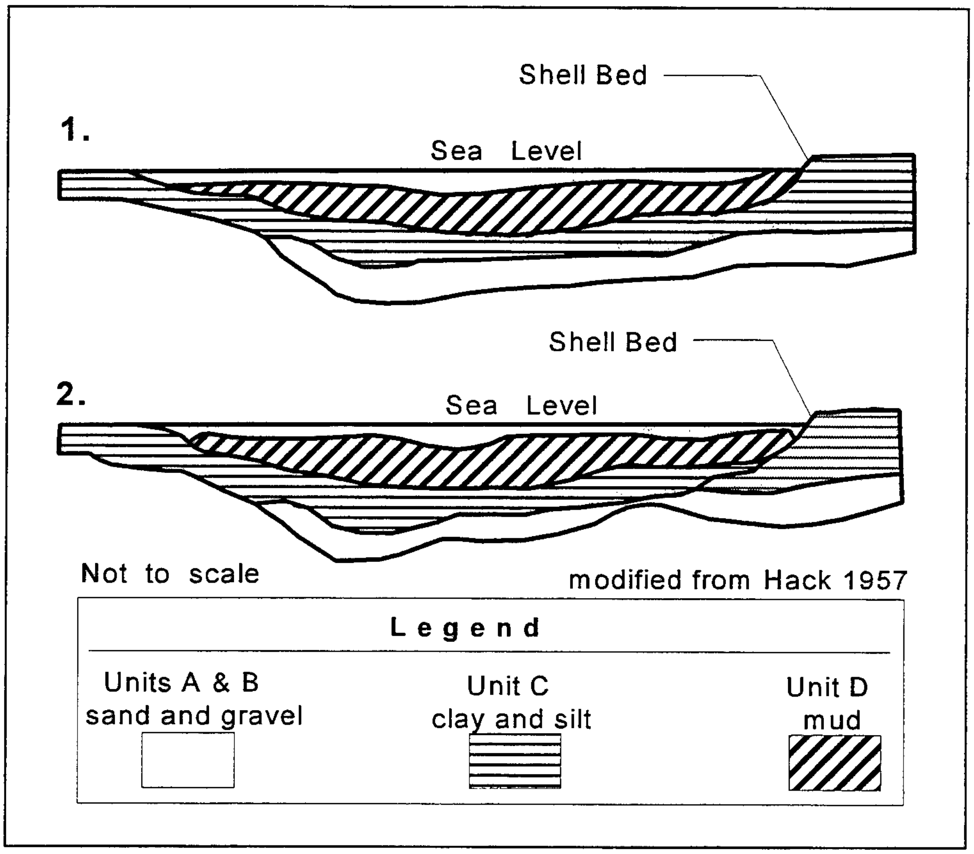


Figure 25. Channel fill deposits of Upper Chesapeake Bay

units, A through D, with unit A as the basal stratigraphic unit. These units are described below:

- Unit A is identified as firm, coarse textured, gravel, and gravelly sand of fluvial origin. This unit tends to occur stratigraphically lower than the other units at the base of the eroded channels in contact with the Cretaceous and Tertiary age units.

- Unit B is composed of sand which may be gravelly in places which occurs stratigraphically above, and frequently in contact with, unit A. Unit B material may also be present as the sediment on the floor of the present day bay along the shoreline margins, within or above unit C material.

- Unit C appears to compose the majority of the channel fill deposits and may be as great as 150 ft thick in some places. The silt and sandy silt of this unit may also be sandy or clayey with occasional localized lenses of gravel. The unit also may contain oyster and other shells, peat, and wood fragments suggestive of estuarine or deltaic environment of deposition.

- Unit D consists of a soft organic silt and mud which comprises the majority of the present day bay floor. This material is very soft with Avery high moisture content and is of Recent age. Coarse-grained deposits occur as benches parallel to the shore on the east and west sides of the bay. These benches are slightly incised by tributary streams (Colman and Halka 1989).

High-resolution seismic reflection profiling

A seismic reflection feasibility study was conducted at three sites on APG-AA (Miller et al. 1995). The goals of the survey were to determine : (a) the feasibility of the technique, (b) the horizontal and vertical resolution of the technique, (c) the optimum source for the site, (d) The optimum acquisition geometries, (e) general processing flow, and (f) a basic idea of the acoustic variability across the site.

The production phase included four nominal 24-fold common data point (CDP) lines: two 0.6-mile lines at the western boundary fence, one 0.3-mile line south of PAAF, and one 0.5-mile line on Spesutie Island (Figure 26). Horizontal resolution limits to depths of around 150 to 200 ft averaged around 30 to 50 ft. Practical vertical bed resolution was around 10 to 15 ft. Scour and fill patterns with a horizontal expanse of less than 200 ft and vertical extent of less than 20 ft were imaged at Spesutie Island. Figure 27 is an interpreted CDP stacked section of major lithologic changes near the PAAF line. Figure 28 compares the interpreted CDP lithologies shown in Figure 27 with a soil boring, WB-SB-15, located along the CDP line.

Well HAR DF 40

Well HAR DF 40 is one of a pair of wells installed on APG-AA in 1985 in the vicinity of the APG stand-by water supply well field (Figure 13, item 7). The ground surface elevation at the well site is 30 ft msl and the well terminates in the saprolitic zone overlying bedrock at el -483 ft msl. The well, which is screened from el -391.5 to -401.5 ft msl, is currently the deepest well on APG-AA. The general lithology as reported on the boring log is similar to that reported for the APG well field, which with regard to Cretaceous units, is located down dip of this location. A gravelly, red clay is indicated from el -110

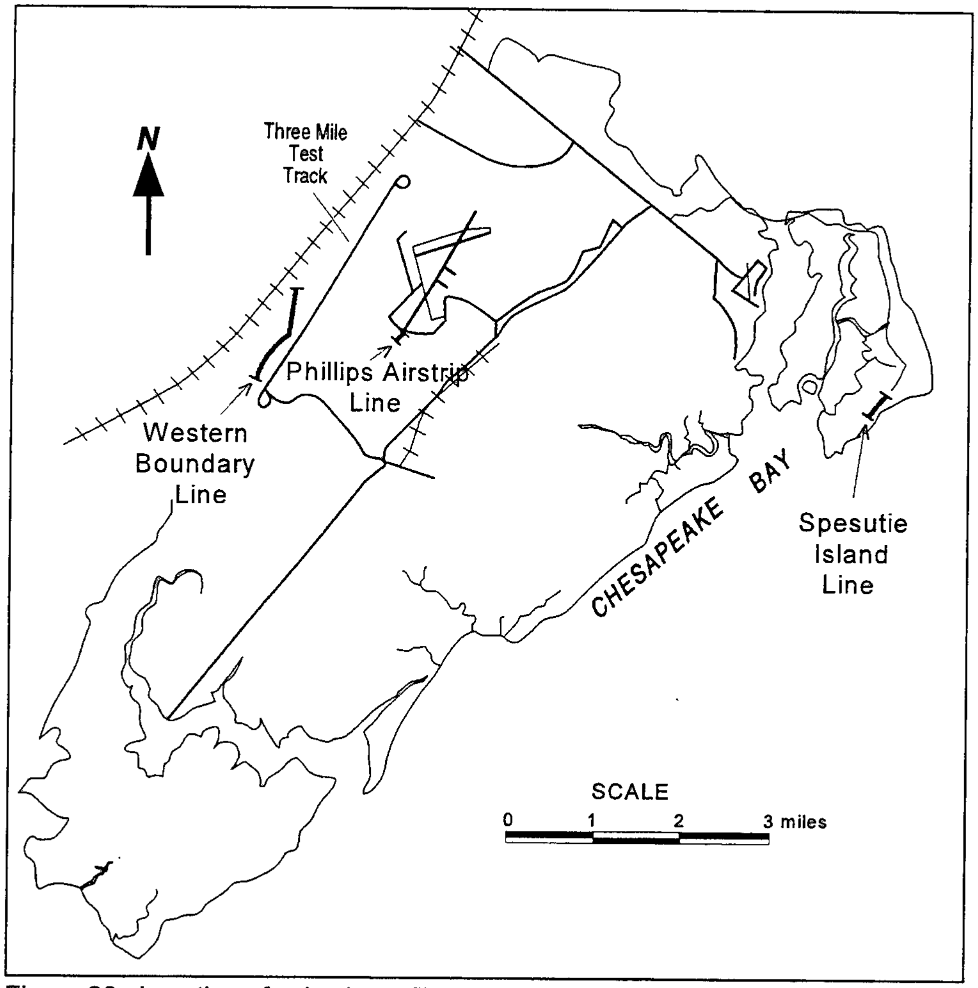


Figure 26. Location of seismic profile lines on APG-AA

to -135 ft msl. A similar lithology is reported beneath the APG standby well field at el -135 ft msl (Moorshead-Siddiqui and Associates, Inc. 1983). There are two gravel zones, each overlain by sequences of silts and clays, from ground surface to the gravelly red clay. The lower gravel zone is located directly above the red gravelly clay mentioned above. The remainder of the log consists of varying mixtures of sands, silts, and clays. Two zones of predominately clay material occur from el -250 to -300 ft msl and -390 to -432 ft msl. A "hard pan green" occurs from el -432 to -451 ft msl. The drillers notes showed a "weather zone" from el -451 to -483 ft msl. Based on observations at other locations and reports from other workers the "hard pan green" probably represents saprolitic material.

Swan Creek outcrops

Steep bluffs, up to 60 ft in height, occur in the northern portion of APG-AA, bordered by the tidal reach of Swan Creek. Recent inspection of this location by the authors revealed the presence of materials ranging from clay, silt and sand lenses to sands with gravels, cobbles, and boulders. Sorting ranged from moderately well to poorly sorted, with some beds containing abundant cobbles

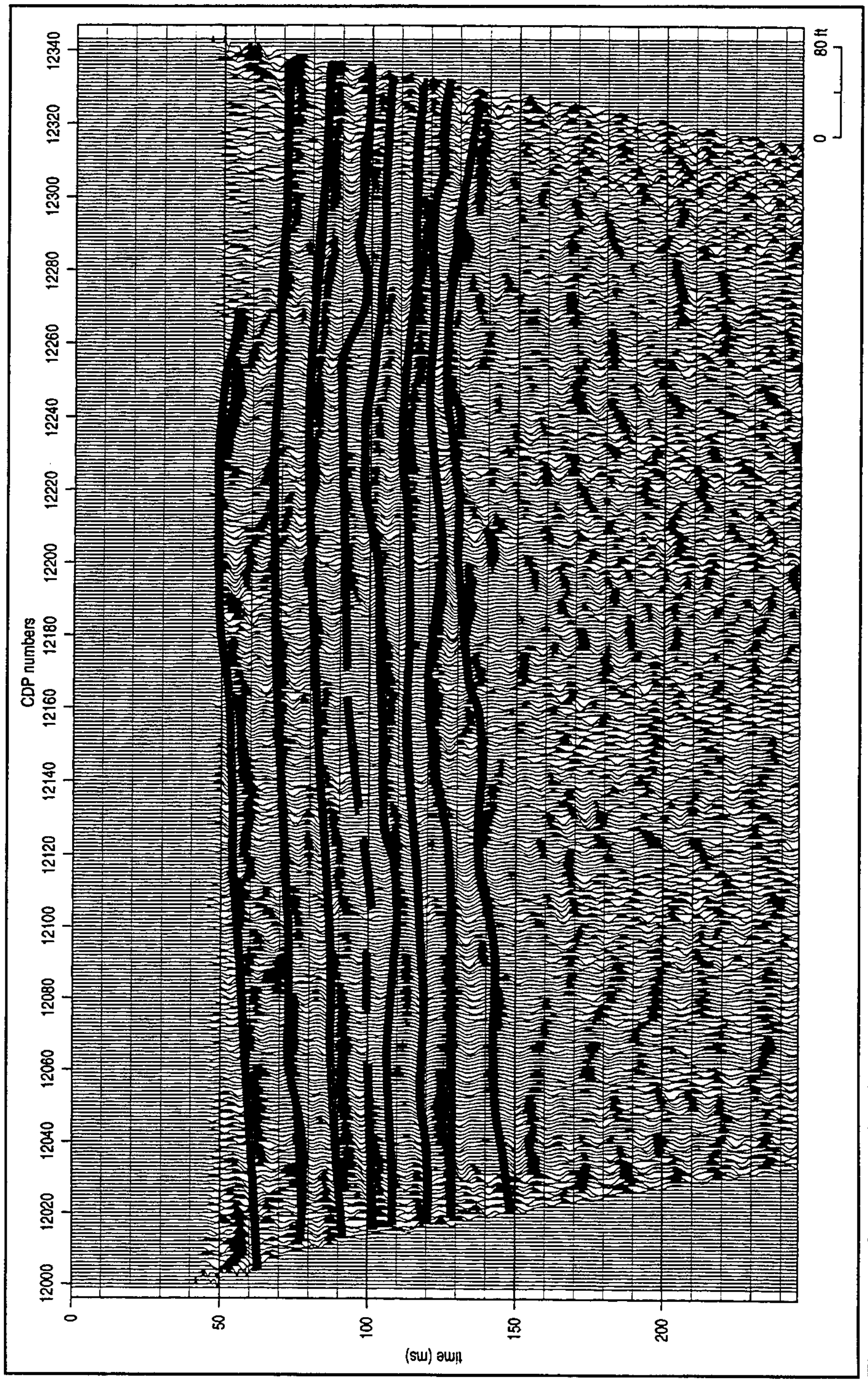


Figure 27. Common depth point (CDP) stacked section with interpred major lithologic changes near airstrip line (from Miller et al. 1995)

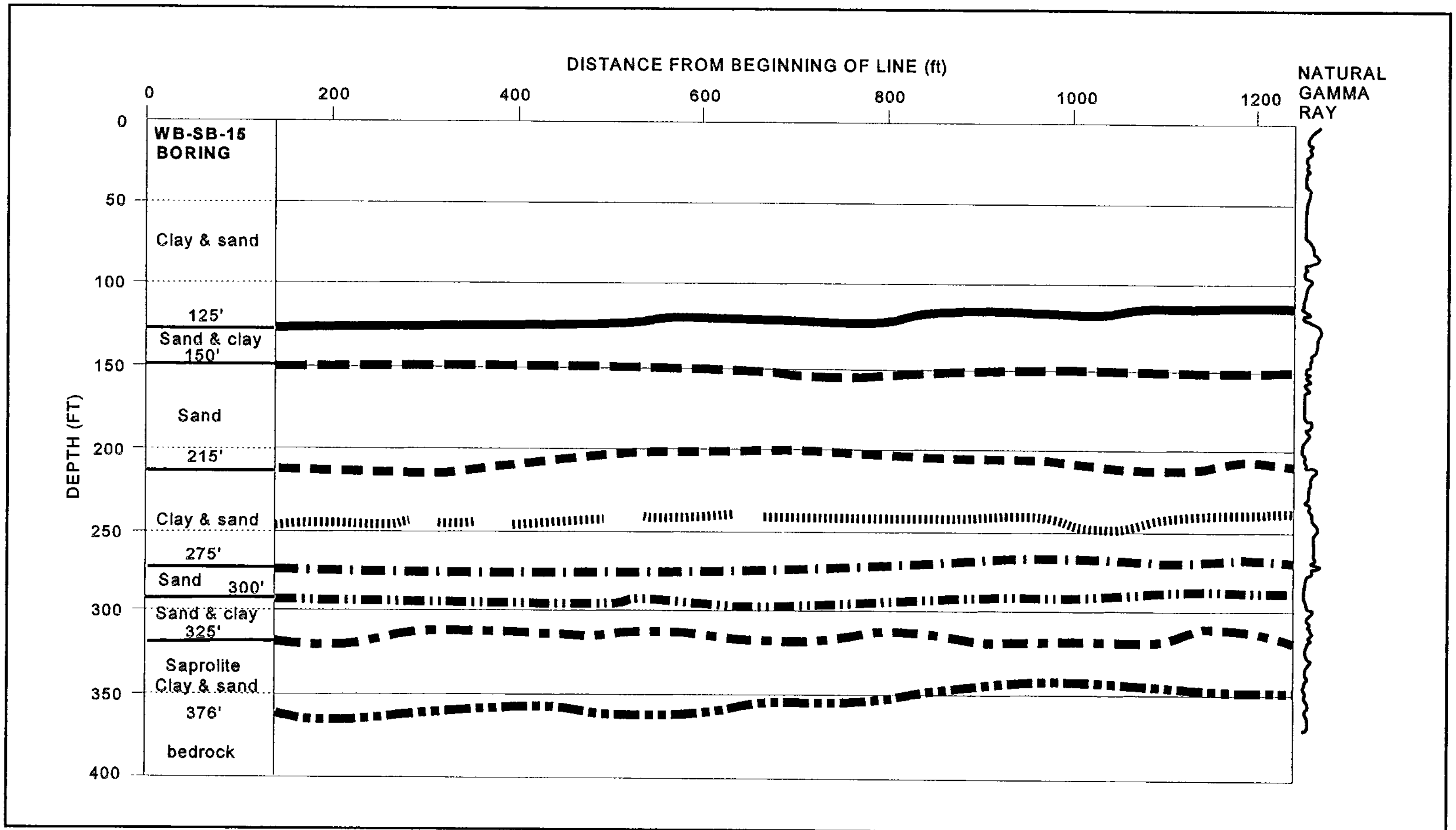


Figure 28. Generalized geologic cross section with lithologies interpreted from borehole geologic and geophysical logs near airstrip line (Miller et al. 1995)

and others relatively uniform fine white or yellow sands. Boulders up to 3 ft in diameter were seen at the base of the outcrops. A measured section located on Gasheys Creek, north of the bluffs on APG-AA, contained a bluish-gray to gray clayey silt at the base of the cut (Owens 1969). Beds of dark-colored clay interbedded with gravelly sand, ranging in total thickness from a few inches to 10 ft thick are reported on the east side of Swan Creek near Oakington, MD. Lignitized plant fragments and plant impressions are occasionally present and the color is noted to weather to a green or bluish green. Samples of wood from this location have been age dated at greater than 35,000 years before present (Owens 1969).

Riverside outcrops

The authors also examined a road cut located in Riverside, MD, on Route 7, east of the intersection with Route 543. This exposure is in the Fall Line Zone at approximately el 120 ft msl. Exposures of the Upland Gravels are nearby. Much of the slope is vegetated but some slumping has occurred near the base revealing green and green-white clay which is presumed to be equivalent to the saprolite found at depth beneath the Coastal Plain.

Superpond

The superpond is a large excavation on APG-AA located on the narrow neck of land between the Bush River and Romney Creek (Figure 29). The authors were able to observe, photograph (Figure 30), and retrieve samples from the dewatered excavation to a depth of -53 ft msl. Five wood samples were collected for radiocarbon dating and nine sediment samples for pollen analysis. All of the radiocarbon dates were reported greater than 40,000 years before present (Tamers 1993). Five of the nine pollen samples analyzed were barren. The four remaining samples were all Pleistocene in age (Brush 1993).

The dominant lithologic feature observed at the site was a dense, dark gray silty clay which covered the base of the excavation and had a vertical exposure of approximately 30 to 40 ft. The upper 15 ft of the gray clay contained an abundance of *Rangia cuneata* shells. *Rangia cuneata* is a brackish water pelecypod present in Maryland during the Pliocene to Pleistocene (Shattuck 1902). Just beneath the gray clay in one area is a 2- to 5-ft-thick layer of organic materials made up of large tree stumps (Figure 31), trees, leaves, and other organic fragments (Figure 30). Immediately beneath one area of the organic materials is a layer of gray sands and gravels 8 to 10 ft thick. Samples obtained from this material for pollen analysis were reported as barren. Several noteworthy hydrologic features became apparent during the inspection of the excavation. Dewatering of the excavation at the time of the authors' visit was accomplished by the placement of a pump in the lowest portion of the site while the excavation continued on adjacent benches. Despite the fact that the excavation was at el -53 ft msl and less than 1,000 ft from the Bush River, infiltration of groundwater through the sidewalls was significantly less than had been anticipated. The authors also observed an open 4-in-diam bore hole within the gray silty clay which formed the floor of the excavation at that time. The geotechnical bore hole, which did not appear to have been grouted when it was

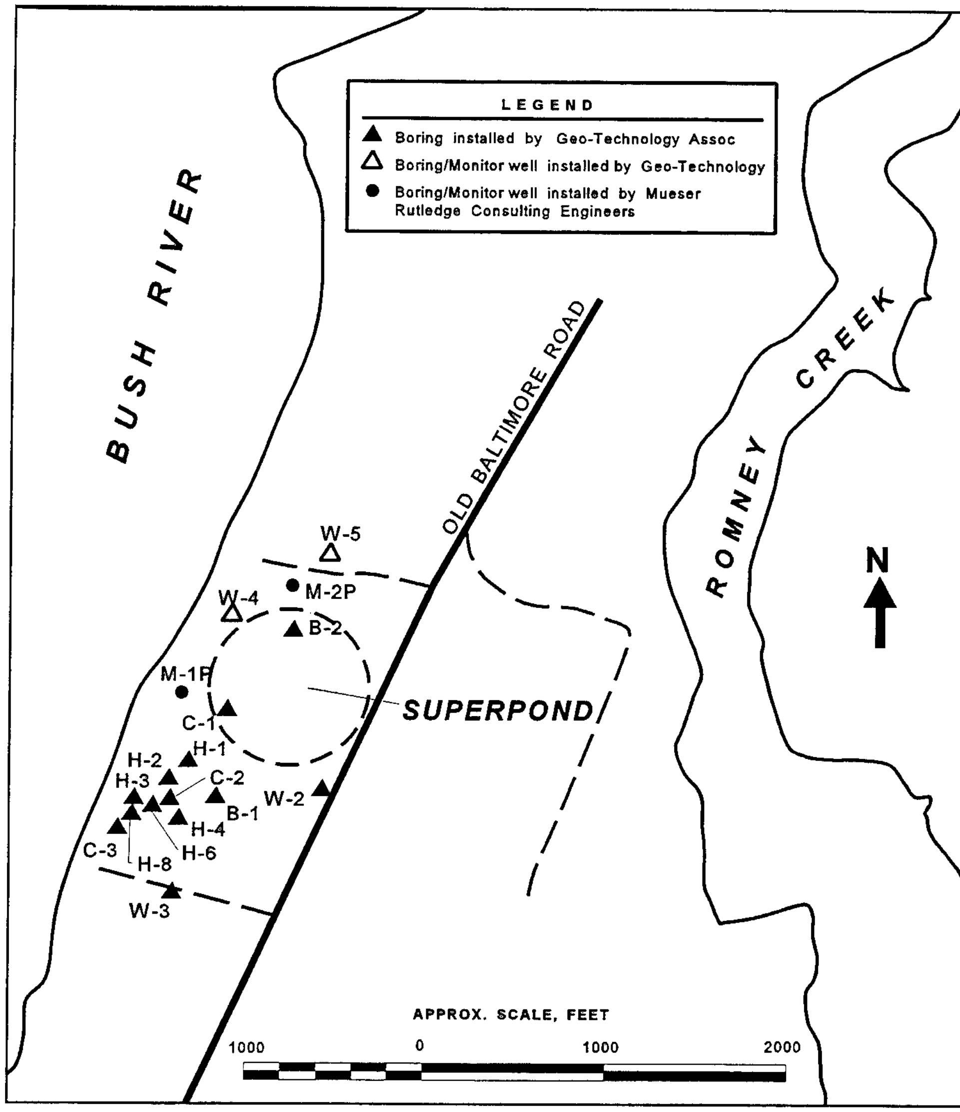


Figure 29. Location of soil borings and monitor wells at Superpond

abandoned, was producing groundwater at a rate of approximately 20 gallons per minute (gpm). The flow rate from the bore hole indicates there is a reasonably productive aquifer beneath the gray silty clay.

The sand and gravel layer may be an old channel topped with washed-in trees, stumps, and other organic materials. No shells and only sparse occurrences of organic materials were seen in the clay beneath the organic layer. Extending from ground surface to the top of the gray silty clay were zones of interbedded coarse sands and gravels with occasional cobbles and boulders, up to 2 ft in diameter, and localized silt and clay lenses. Iron-cemented hardpans, often of considerable lateral extent, were present in this unit. The hardpans contain occasional "pockets" of organic materials.

The upper sand and gravel zone is presumed to be equivalent to the Talbot Formation described earlier. However, the upper sand and gravel zone may be equivalent to the Late Pleistocene Kent Island Formation based on the general

Figure 30. Superpond excavation at APG-AA

Figure 31. Organic materials in Superpond excavation

lithologic characteristics, the stratigraphic relationship to the underlying gray silty clay and the presence of abundant organic matter. The Kent Island Formation has been identified on the eastern shore of the Chesapeake Bay approximately 40 miles south of APG-AA (Owens and Denny 1979).

The southeastern wall of the excavation differed from other areas in that a mottled, red, and gray clay was present from the base to near ground surface (see Figure 30). The color and texture of this material were conspicuously different from the rest of the exposed material and may represent Cretaceous age sediments.

Groundwater was also noted to be entering the excavation along the walls in the sand and gravel zones. Iron-cemented hardpans were present at various depths and extended laterally distances of a few feet to approximately 100 ft. Groundwater was frequently dripping or flowing from the tops of the hardpan ledges indicating the hardpans was acting as barriers to the downward flow of groundwater.

Zones of abundant organic material ranging from a few inches to several feet thick and extending from a few feet to tens of feet laterally were present throughout the walls of the excavation. The organic materials ranged from packed masses of recognizable woody vegetative matter, such as tree branches, stumps, and leaves, to tight masses of organic clay. The largest organic zone observed in the excavation ranged from 1 to 6 ft thick and extended approximately 400 ft laterally (see Figure 30). Smaller organic zones occurred randomly in the sands and gravels.

Western Boundary Area

The Western Boundary Area (WBA) is generally bounded by the Bush River and APG-AA boundary to the west, Old Baltimore Road/Michaelsville Road to the south and east, and the APG-AA boundary to the north. The WBA is shown as area 13 in Figure 13. The objective of the investigations was to define the extent of contamination within this area. Harford County and City of Aberdeen production wells, which are located within this area, were of particular concern. The Fire Training Area/Western Boundary Investigation (GP 1993) was completed in 1993. The WBA Remedial Investigation (WBA RI) began by the USAEDB in 1993 was completed in 1996.

The Fire Training Area/Western Boundary Investigation was conducted to generate additional hydrogeologic and groundwater quality data for the area located between Perryman, Maryland, and the AFTA (Figure 32). The average elevation for the study area ranges from 40 ft msl near the western boundary of APG-AA to 60 ft msl near the PAAF. The data are intended to supplement previous studies conducted to define the subsurface environment and to assess the potential for contaminant migration from the AFTA. Included in the scope of the project were four exploratory soil borings and the installation of 26 piezometers and 13 monitoring wells.

The subsurface characterization developed from this investigation indicated as many as four aquifers, interconnected to varying degrees, exist beneath the WBA APG-AA. Over most of the area the upper aquifer is reported to encompass the Talbot Formation and the upper sands of the Potomac Group. This conclusion is consistent with the findings of the Harford County Test Well Program report (Whitman, Requardt, and Associates 1976). Locally, discontinuous clays function as aquitards to divide the upper aquifer into two interconnected water-bearing units. The upper aquifer is bounded below by an apparently continuous, stiff, gray clay, ranging in thickness from 2 to 20 ft. All of the wells and piezometers installed as a part of this effort appeared to be screened in the upper aquifer.

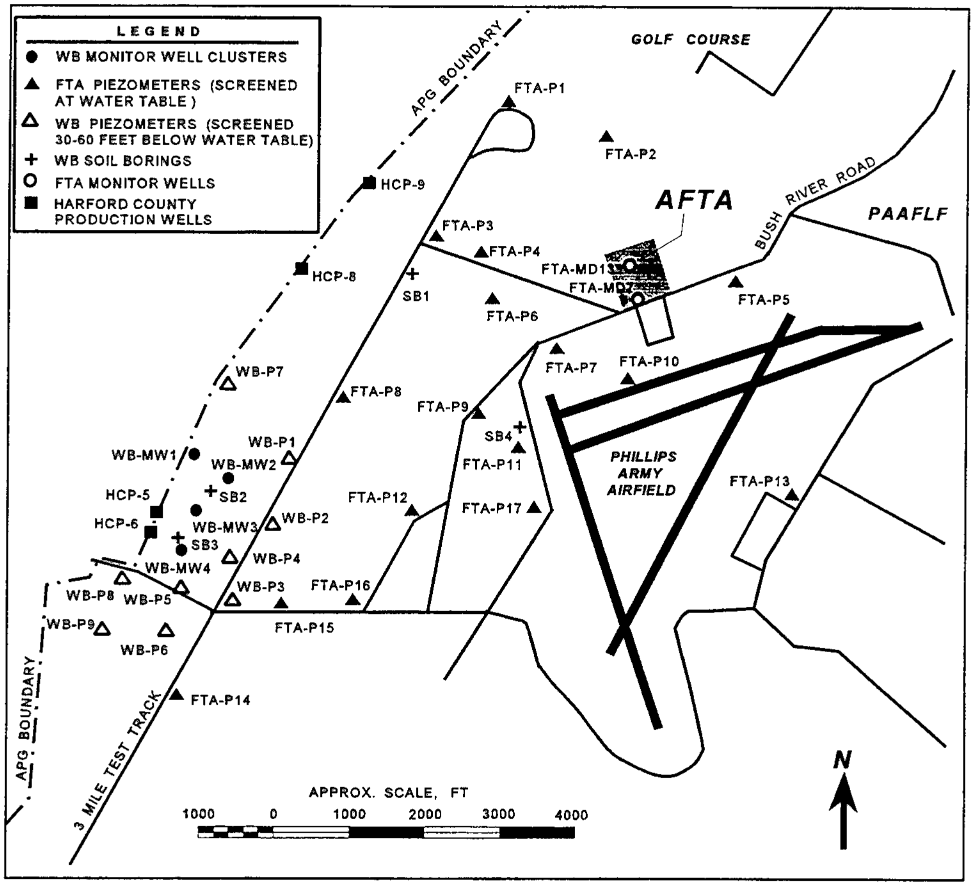


Figure 32. Location of monitor wells, piezometers, and soil borings in the Fire Training/Western Boundary Investigation

The two intermediate aquifers consist of bodies of fine gray sand. The aquifers are separated by a stiff clay as much as 20 ft thick. Each of these aquifers is confined below by a stiff, grey-red mottled clay. The lateral continuity of the intermediate aquifers cannot be determined from the data available. It is possible that one or both may be interconnected to the upper aquifer or each other. It also appears that the deeper of the two intermediate aquifers may pinch out near boring WBSB-4 located in the eastern portion of the study area near PAAF.

The deep aquifer was encountered in only one boring, WBSB-2, which is located near the western boundary of APG-AA. This aquifer consists of 5 ft of tan to gray sand and clay. The deep aquifer overlies the basement rock at this location with no saprolite present. The deep aquifer is of unknown lateral extent. Insufficient data are available from this location to evaluate the hydrogeologic function of the bedrock. Several of the borings conducted during this effort are incorporated into the hydrogeologic interpretation presented later in this report.

The WBA RI generally includes the area between Old Baltimore Road, Michaelsville Road, Swan Creek, and the western boundary of APG-AA. The off-post area between the western boundary and Bush River are also included in

the study area. The primary objectives of the study were to characterize the nature and extent of contamination in the WBA and evaluate potential remedial actions, if needed.

Field work in the WBA was completed in the summer of 1995. The data are in three separate USAEDB (1996a, b, and c) reports. The field work included:

a. Four deep soil borings (WB-SB-13 through -16) to bedrock to better define the geology and hydrogeology of the WBA

b. Eighteen cluster wells (WB-MW-5 through 22) with three wells per cluster (pilot soil borings were drilled to a depth of approximately 150 ft at each cluster well site)

c. Five hydropunchs (WB-HP-1 through -5) at PAAF

d. Thirteen piezometer clusters (WB-P-10 through -22) with one shallow and one deep piezometer per cluster

e. Nine water table piezometers (PLP-17 through -25) in the area of the City of Aberdeen production wells

f. Three piezometer clusters (WES-PZ-6 through -8) northwest of MLF with one shallow and one deep piezometer per cluster

g. One production well (AA-WW-1)

The location of the borings, monitor wells, piezometers, and hydropunchs installed during this investigation are shown on Figure 33.

Prior to the WBA RI, the geologic data were primarily confined to many small sites scattered across APG-AA. The deeper geologic data were primarily in areas 4, 5, and 6 on Figure 13. The geologic data from the WBA RI provided data to:

a. Better define the top of bedrock

b. Identify and map three Quaternary terraces

c. Identify and map the top of the Cretaceous

d. Better understand the hydrogeology

Using the existing boring data and the boring data from the WBA RI, a contour map of the top of Precambrian metamorphic bedrock and the top of the Cretaceous at APG-AA were constructed (Figures 34 and 35). The WBA boring data, particularly to the east and south of the PAAF, provided enough additional data to other workers (Dunbar et al. 1997) to identify and map a series of three Quaternary terraces on APG-AA.

The top of bedrock map, top of Cretaceous map, terrace maps, and boring data were used to construct six geologic cross sections (Figures 36 through 43). The location of the cross sections is shown on Figures 34 and 35.

Geomorphic Study of APG-AA

A geomorphic study of the APG-AA (Dunbar et al. 1997) was conducted to define the landforms and their development as part of the regional groundwater model of the APG-AA. The geomorphic study has identified three Quaternary terraces at the APG-AA from the topography and existing boring data (Figure 44). The three terrace surfaces represent the former floodplain of an ancestral

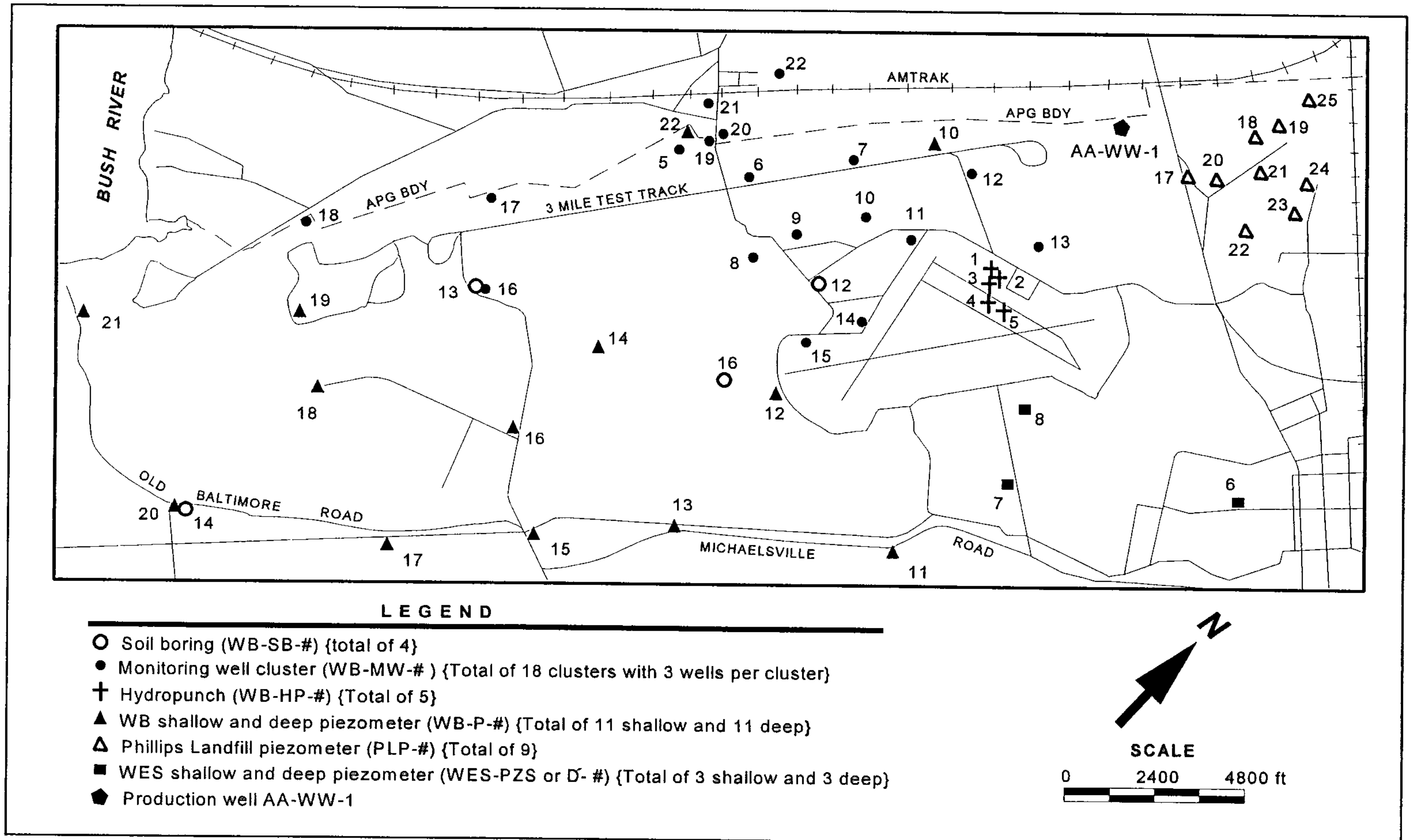


Figure 33. Location of borings, wells, and piezometers installed during Western Boundary Area RI

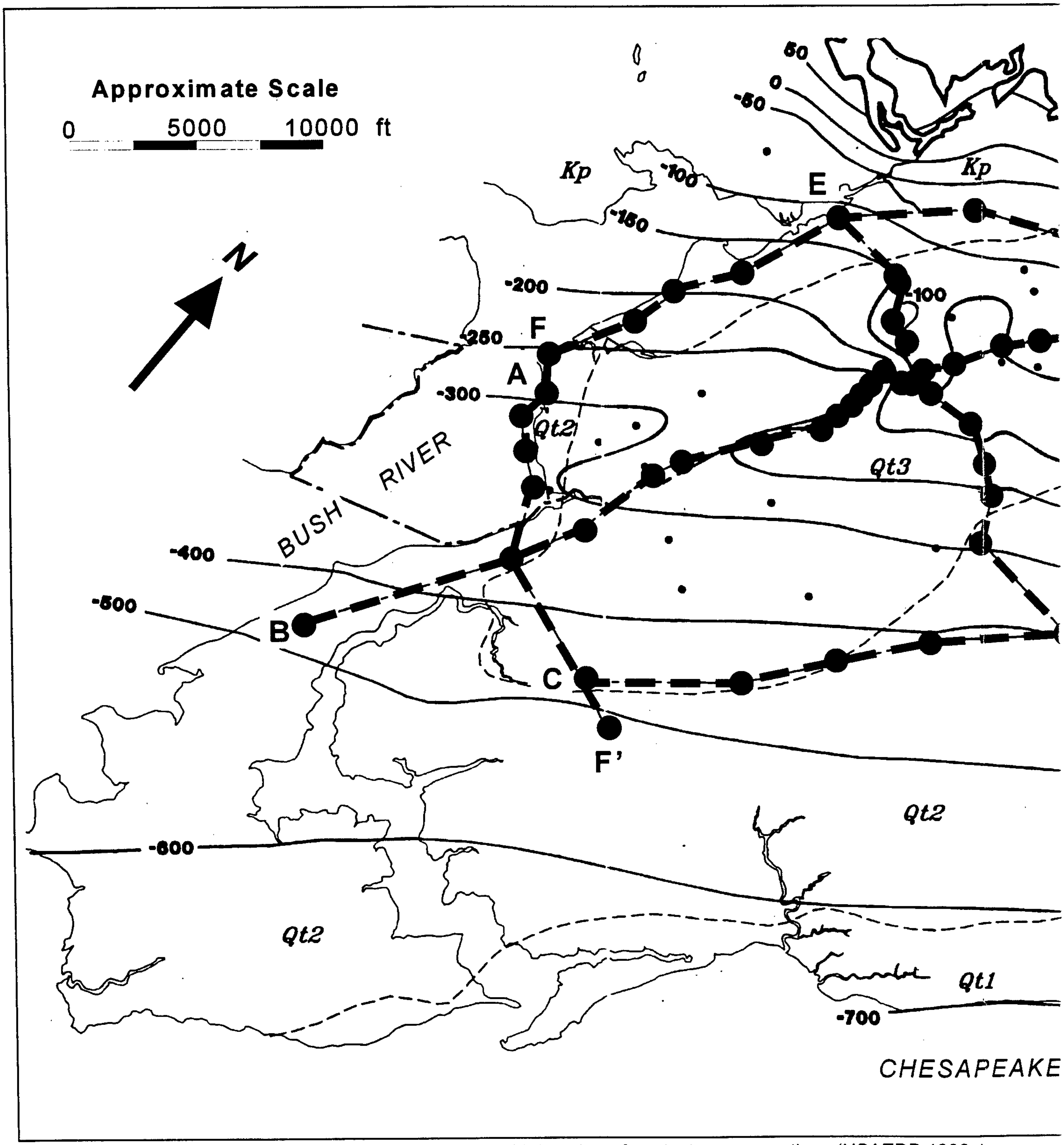
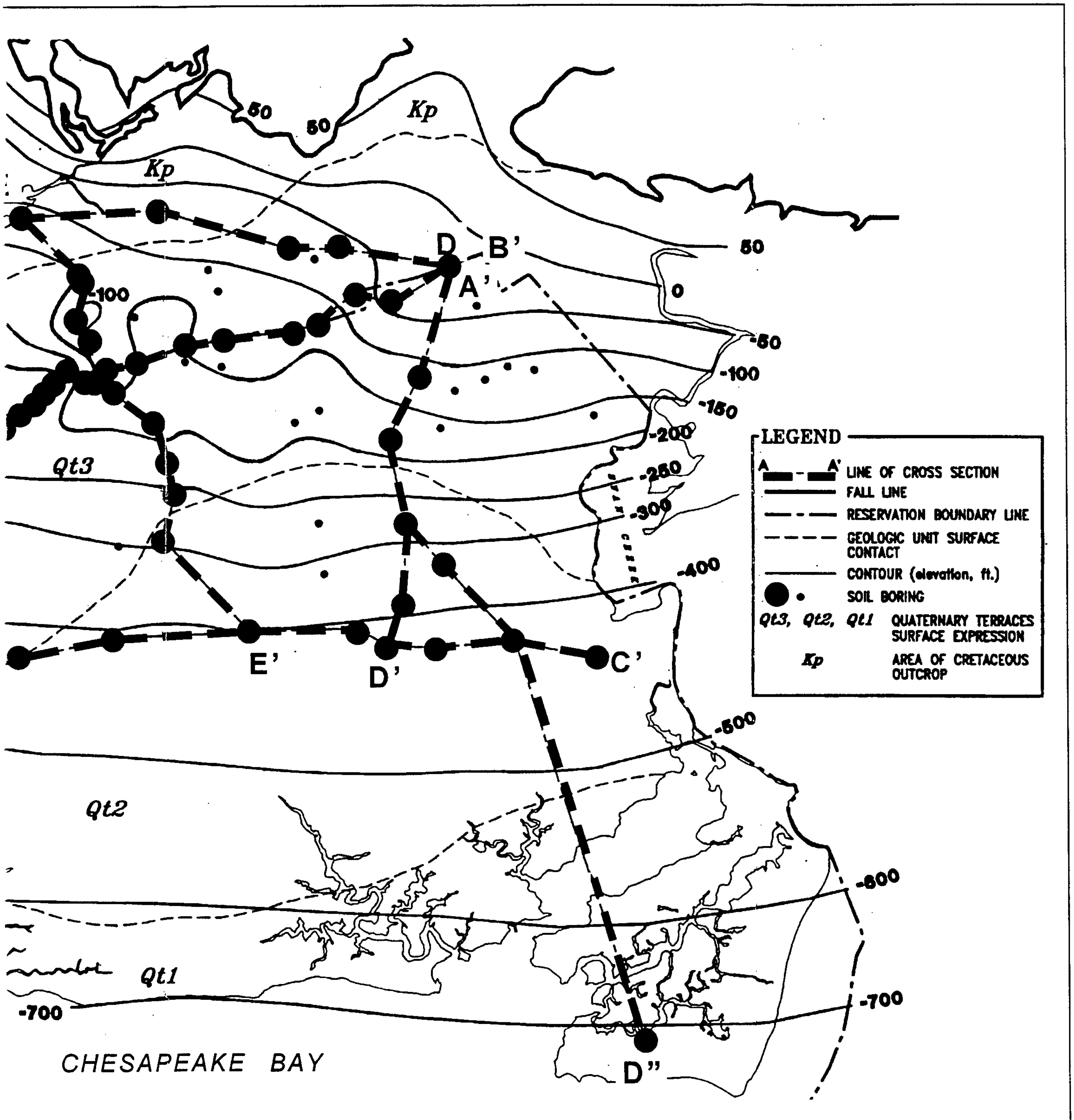


Figure 34. Contour map of top of metamorphic bedrock with location of geologic cross sections (USAEDB 1996a)



s (USAEDB 1996a)

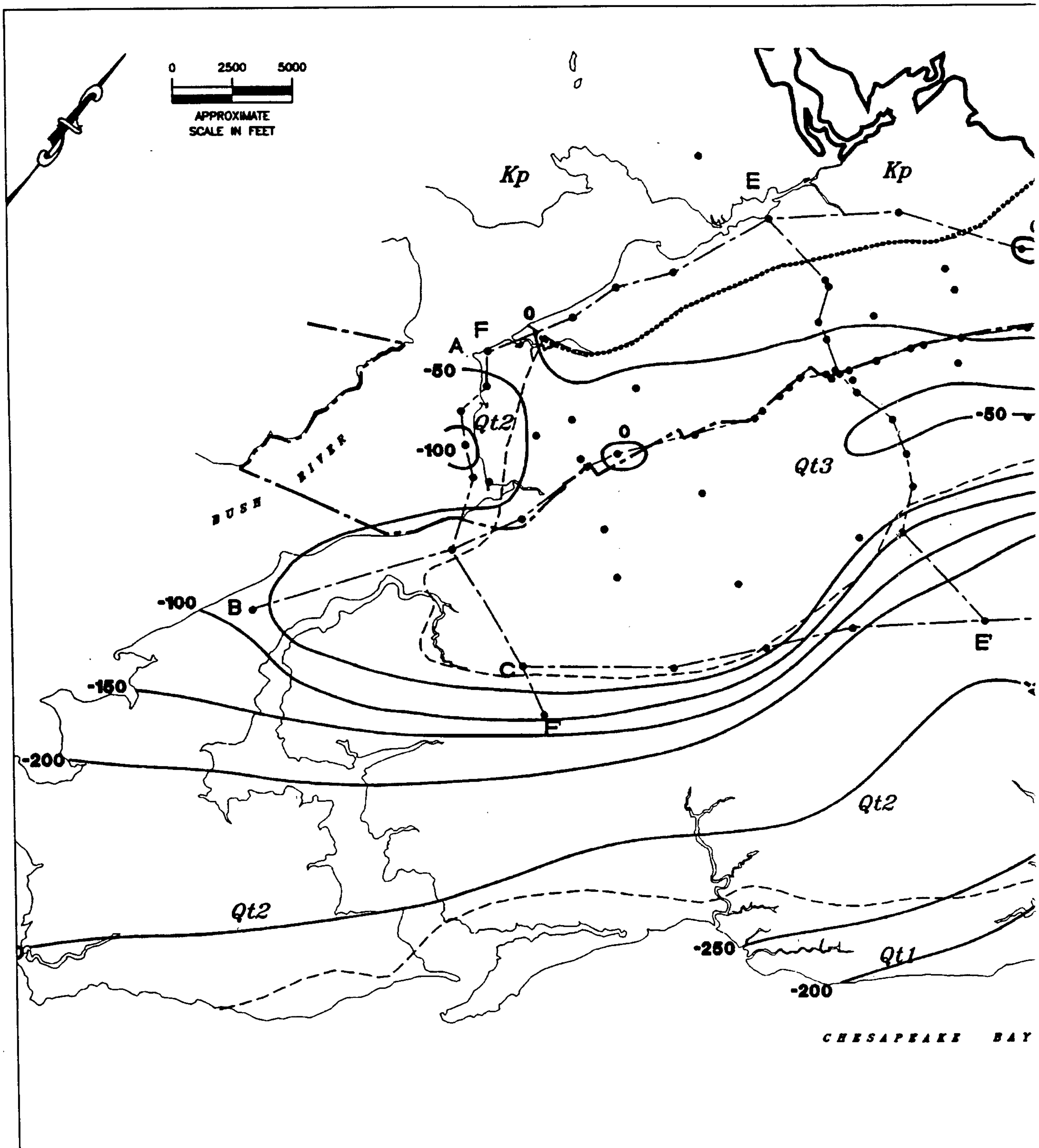
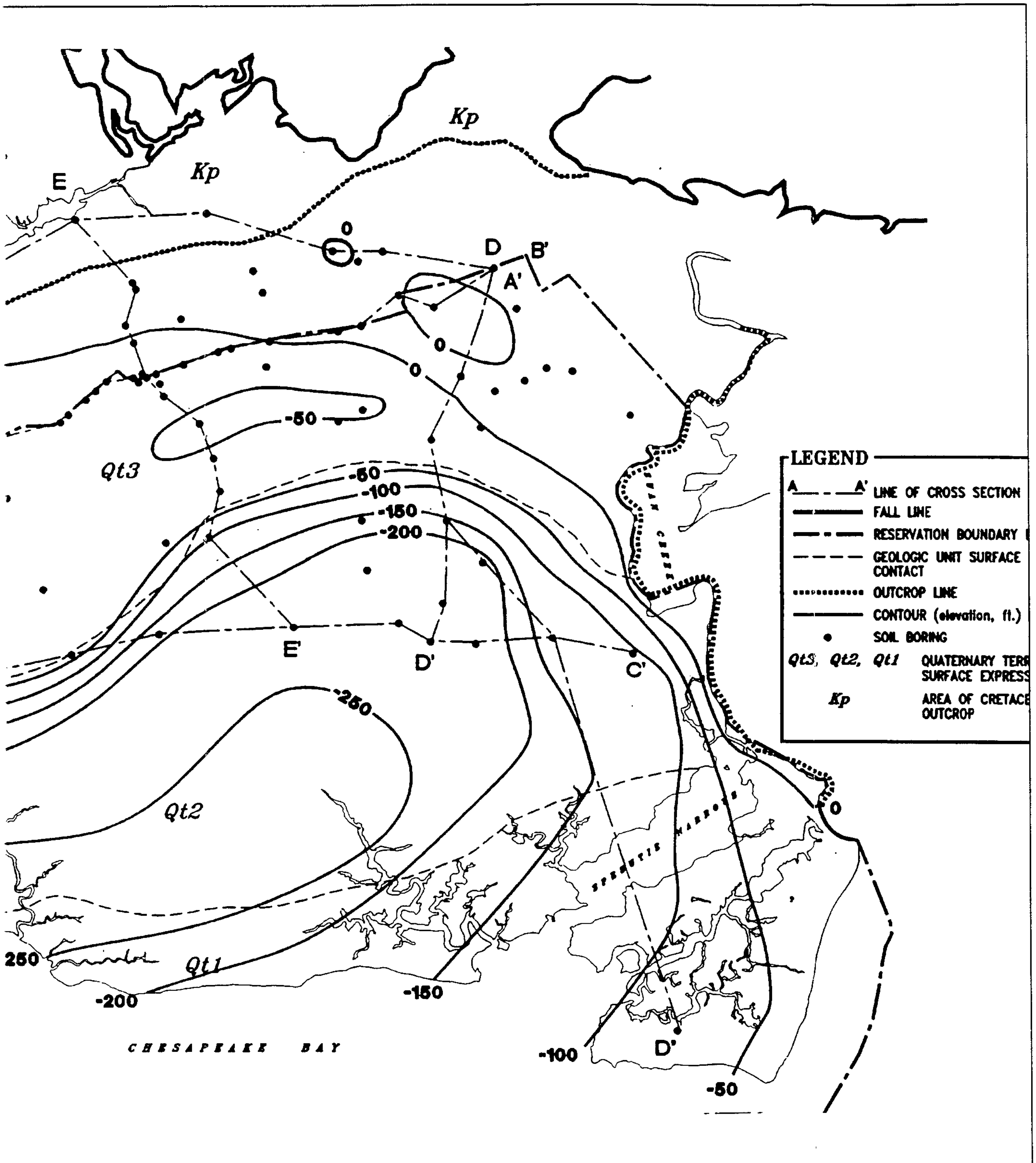


Figure 35. Top of Cretaceous map on APG-AA (USAEDB 1996a)



Kp
Kp
E
0
D
B'
A'
0
0
-50
Qt3
-50
-100
-150
-200
E'
D'
C'
250
Qt2
250
Qt1
-200
-150
CHESAPEAKE BAY
-100
D'
-50
0
LEGEND
A — — A' LINE OF CROSS SECTION
FALL LINE
RESERVATION BOUNDARY
GEOLOGIC UNIT SURFACE CONTACT
OUTCROP LINE
CONTOUR (elevation, ft.)
SOIL BORING
Qt3, Qt2, Qt1 QUATERNARY TERR SURFACE EXPRESS
Kp AREA OF CRETACE OUTCROP

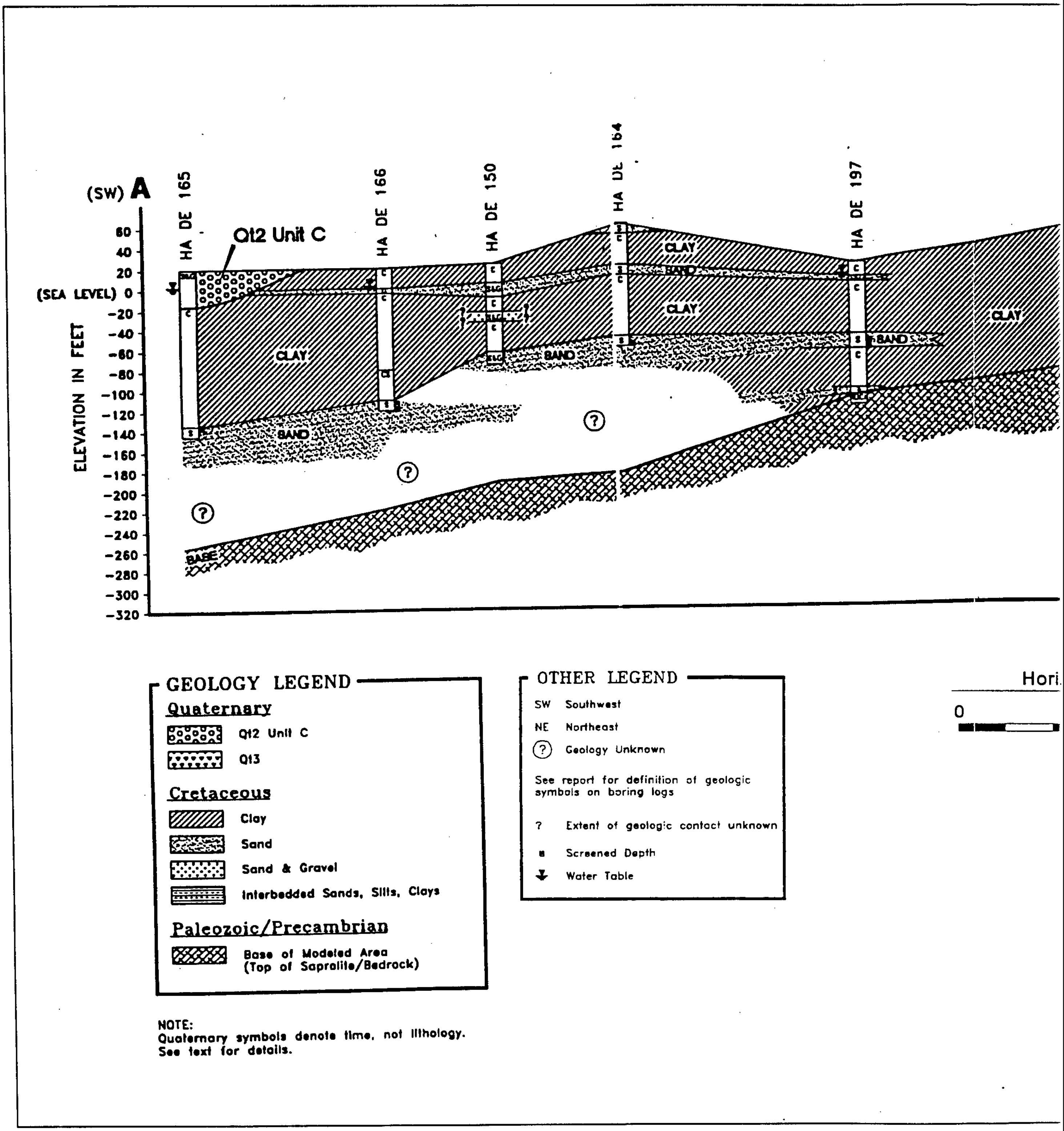
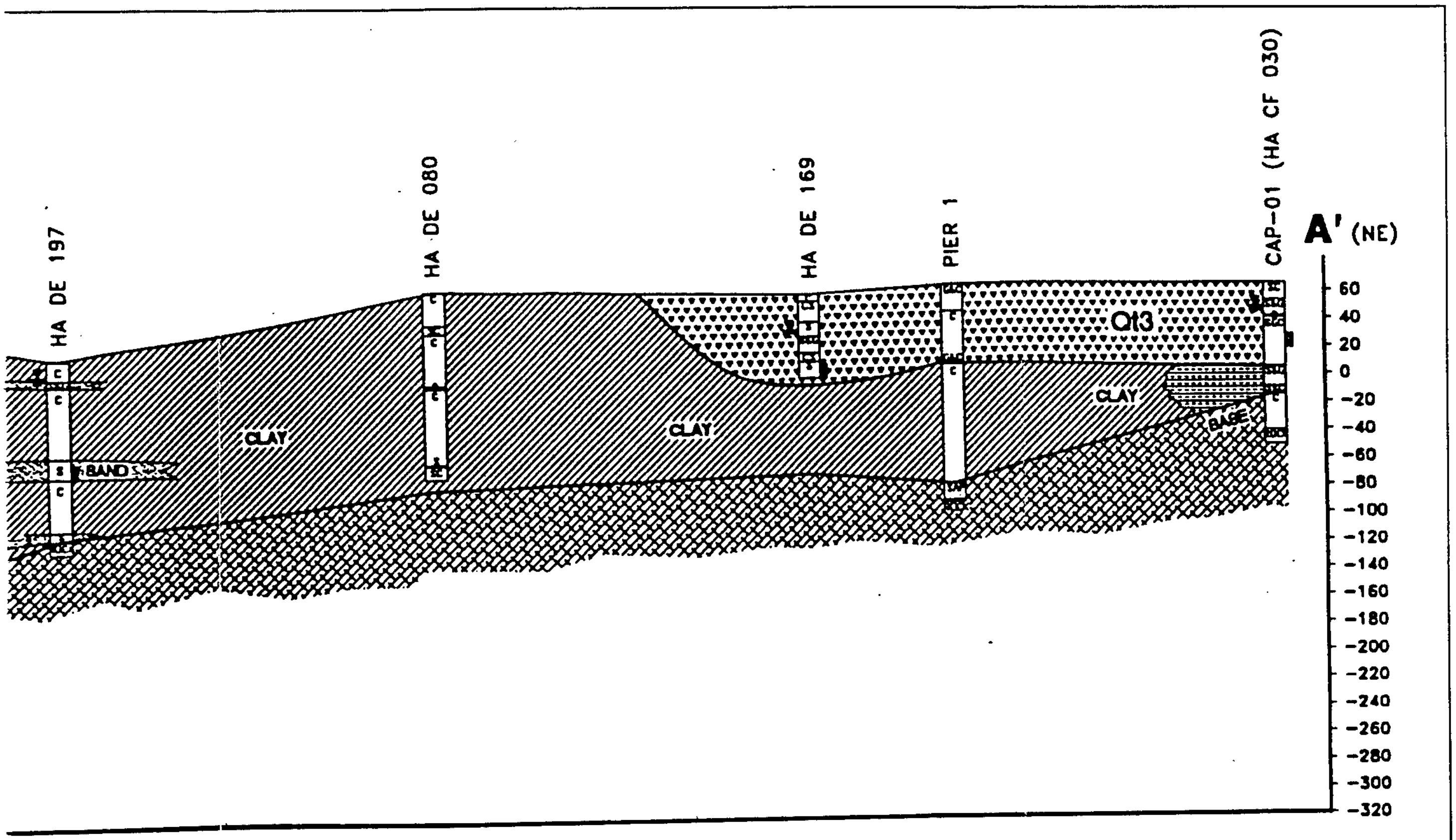
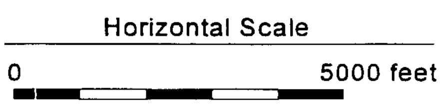


Figure 36. Cross section A-A' (USAEDB 1996a)





SYMBOLS USED IN CROSS SECTIONS	
C	Clay
SLC	Silty Clay
CS	Clayey Sand
SC	Clay & Sand or Sandy Clay
G&S	Gravel & Sand or Clay and Gravel
SL	Silt
SSL	Sandy Silt
SLS	Silty Sand
CSL	Clayey Sand
S	Sand
S&C	Sand & Clay
S&G	Sand & Gravel
G	Gravel
SGC	Sand & Gravel & Clay
SAP	Saprolite
ROCK	Bedrock
WAT	River or Bay

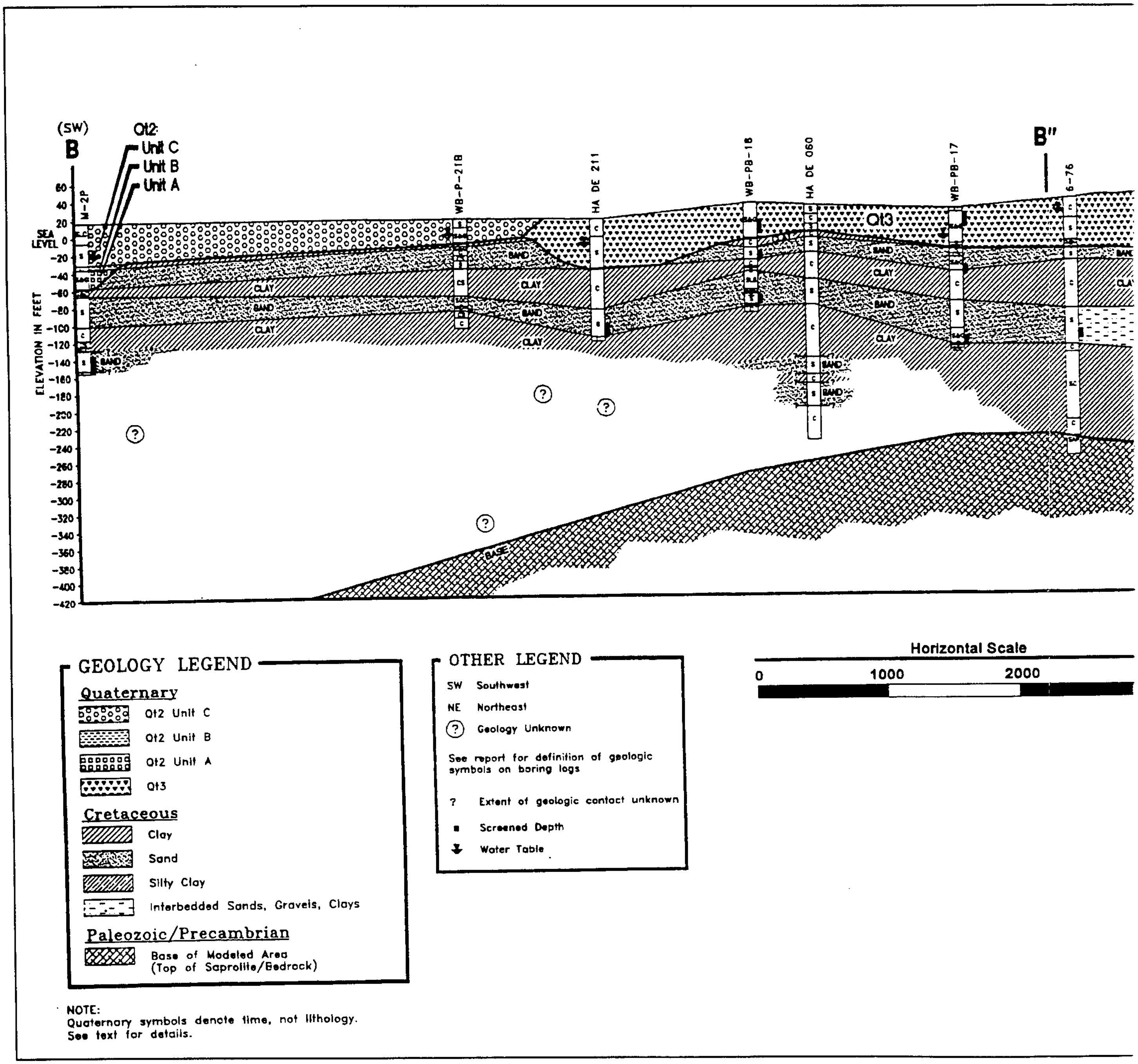
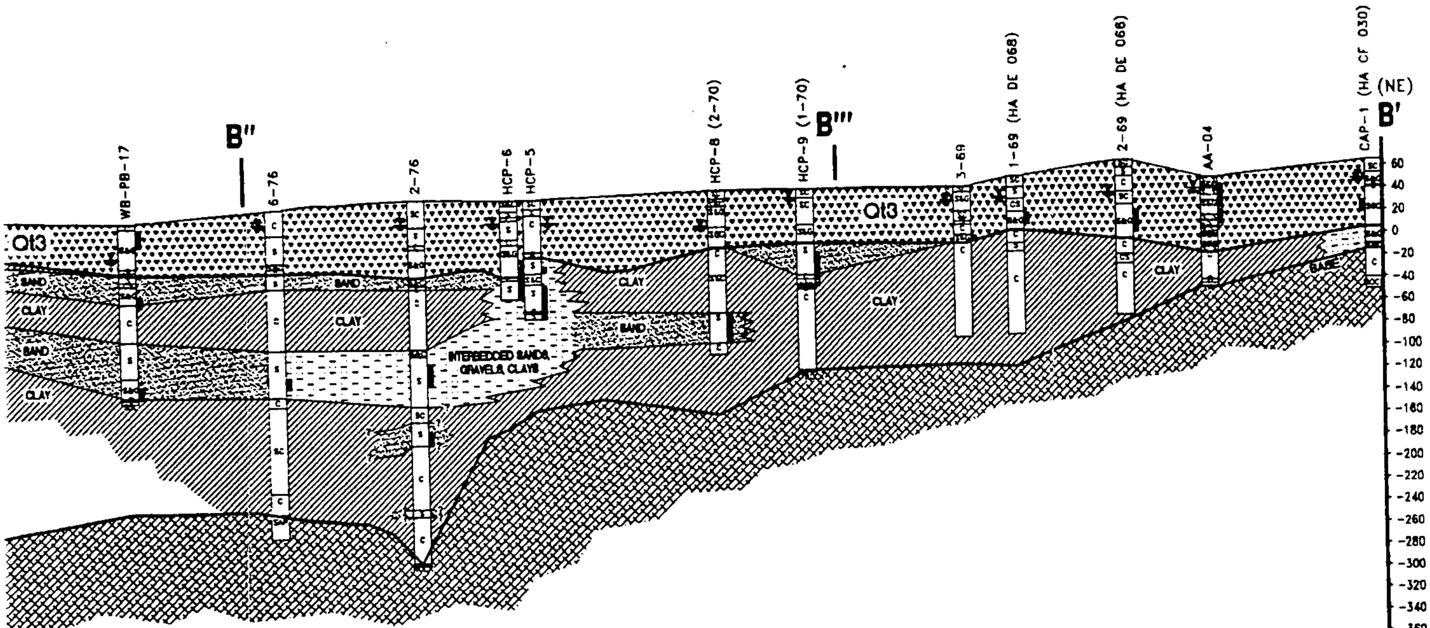
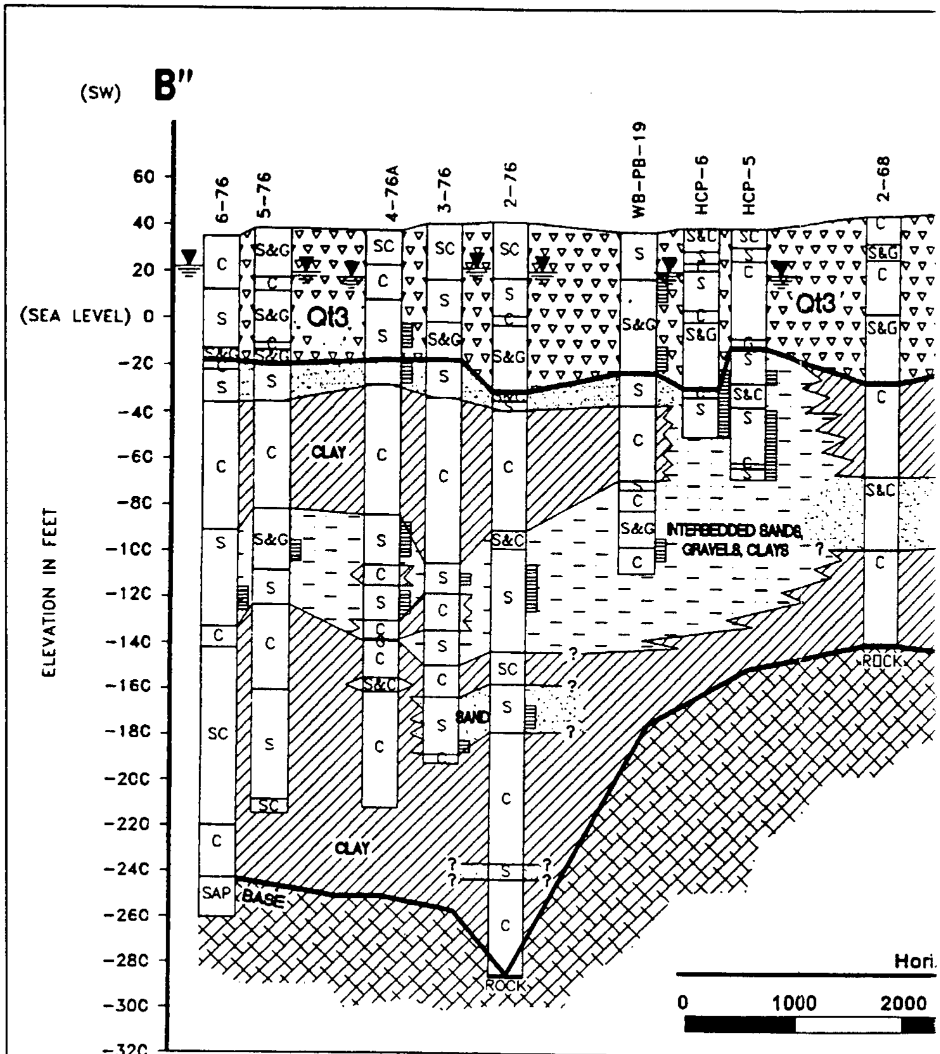


Figure 37. Cross section B-B' (USAEDB 1996a)



Horizontal Scale

1000 2000 3000 feet



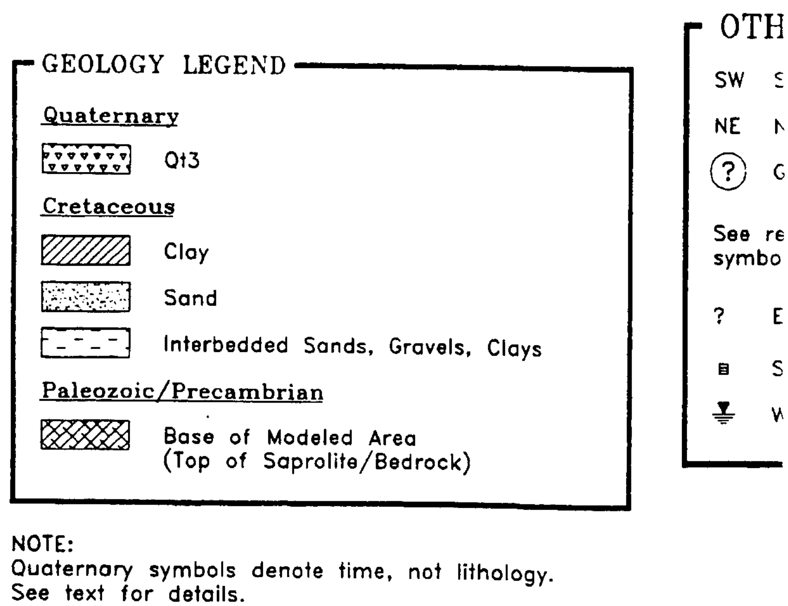
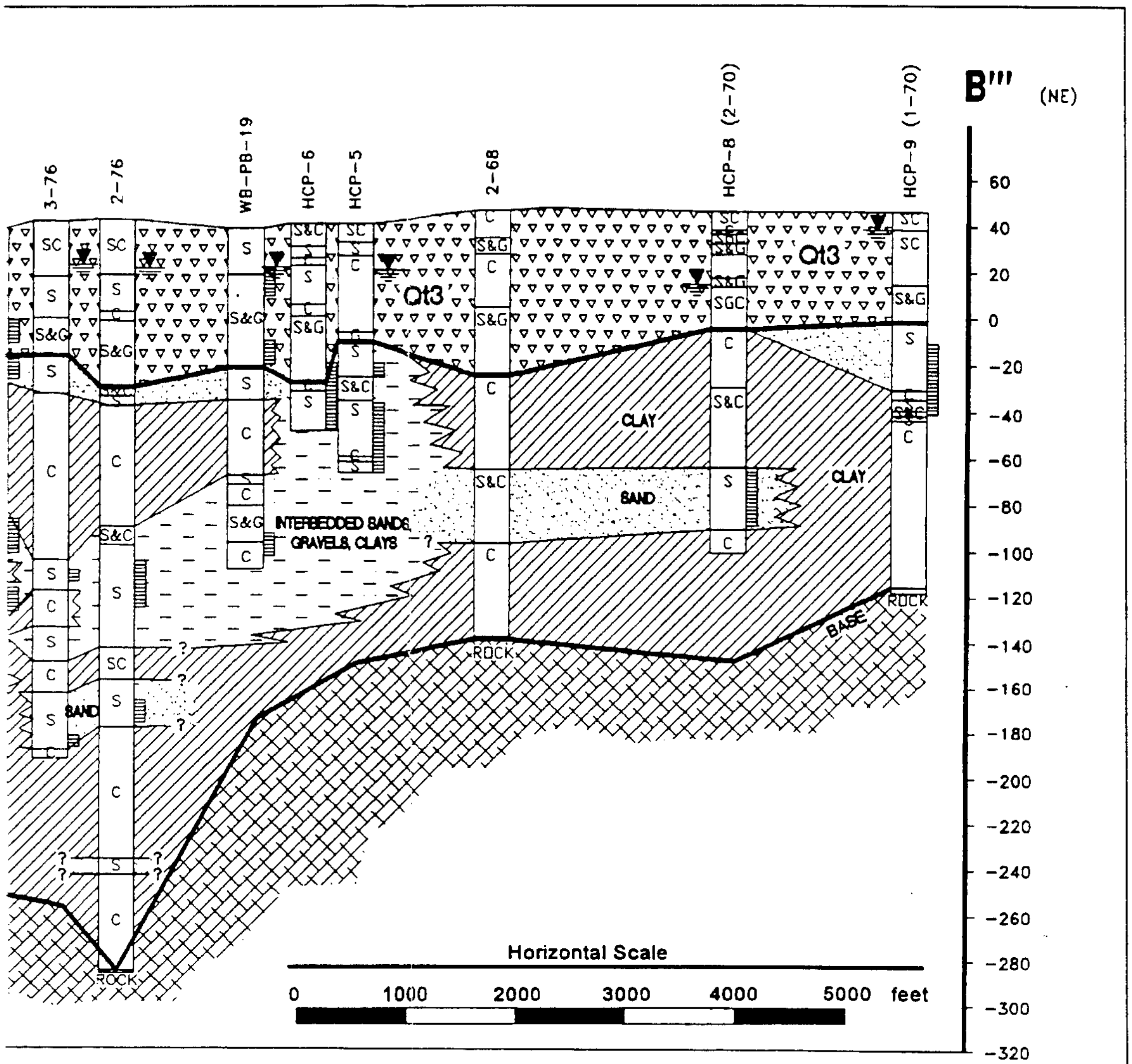


Figure 38. Cross section B"-B'" (USAEDB 1996a)



:ND

ıded Sands, Gravels, Clays

mbrian

f Modeled Area
' Saprolite/Bedrock)

OTHER LEGEND

SW Southwest

NE Northeast

(?) Geology Unknown

See report for definition of geologic symbols on boring logs

? Extent of geologic contact unknown

⊟ Screened Depth

Water Table

denote time, not lithology.

(USAEDB 1996a)

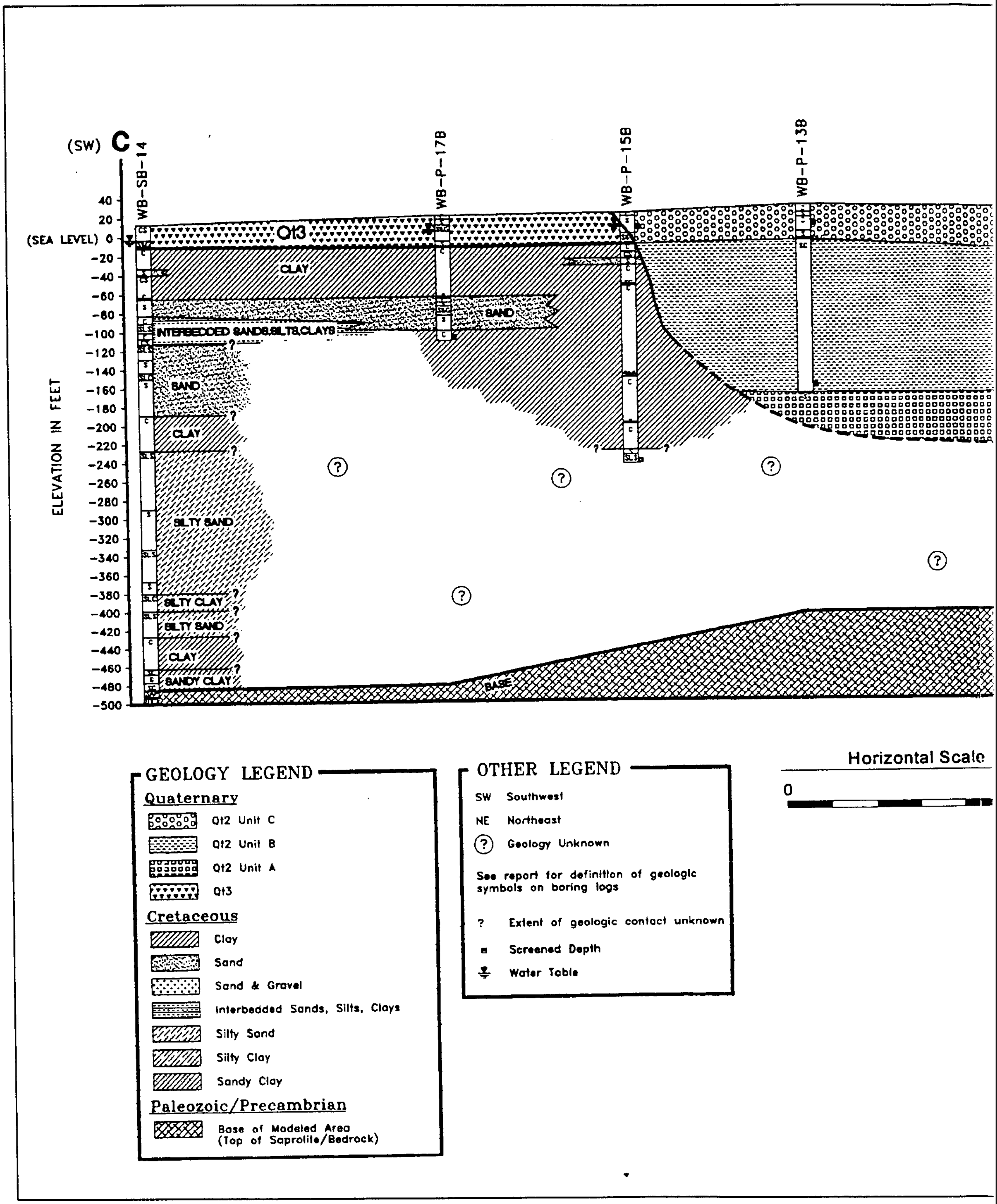
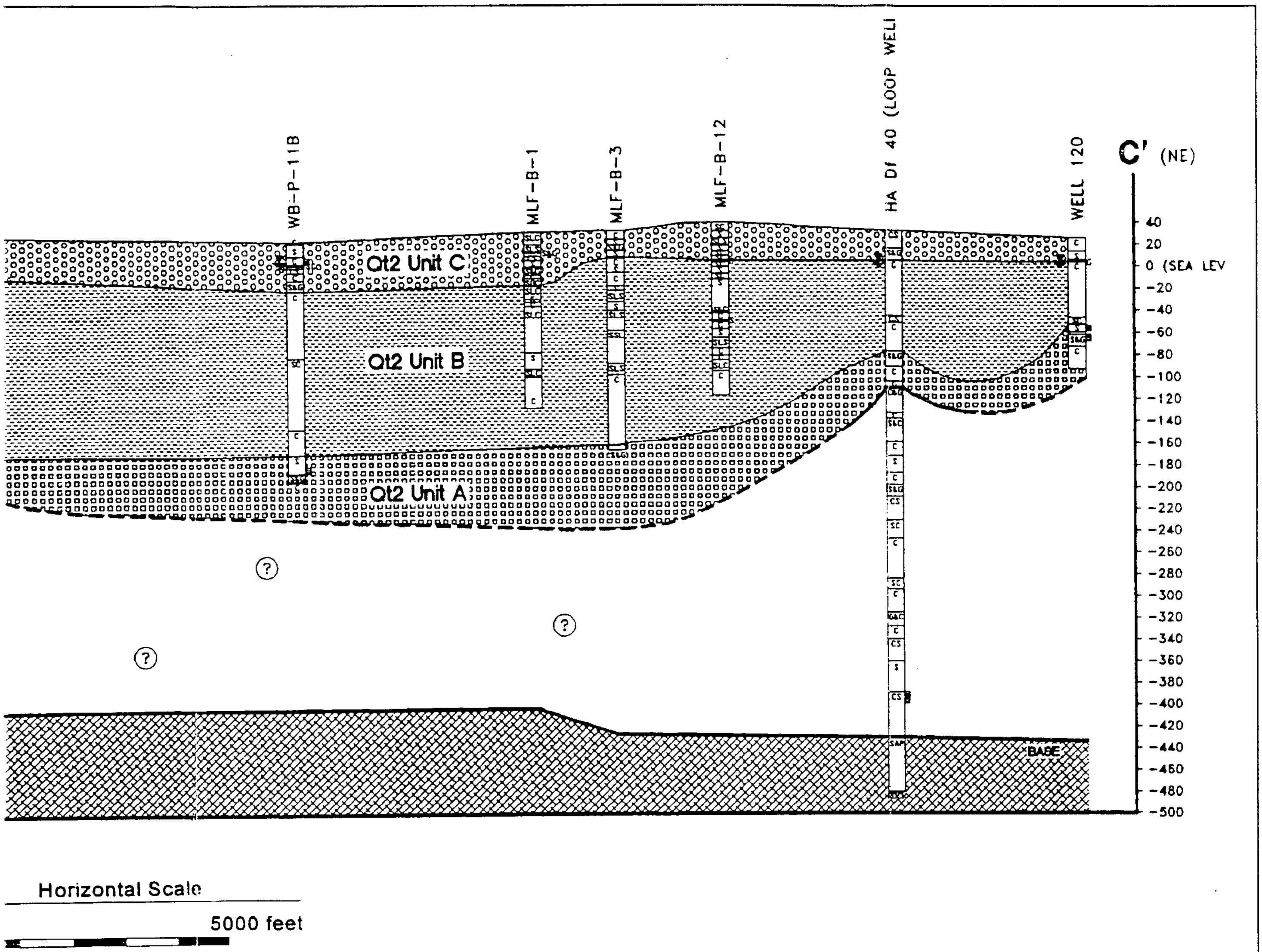


Figure 39. Cross section C-C' (USAEDB 1996a)



WB-P-11B
MLF-B-1
MLF-B-3
MLF-B-12
HA Df 40 (LOOP WELL
WELL 120
C' (NE)
Qt2 Unit C
Qt2 Unit B
Qt2 Unit A
40
20
0 (SEA LEV
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
-320
-340
-360
-380
-400
-420
-440
-460
-480
-500
BASE
Horizontal Scale
5000 feet

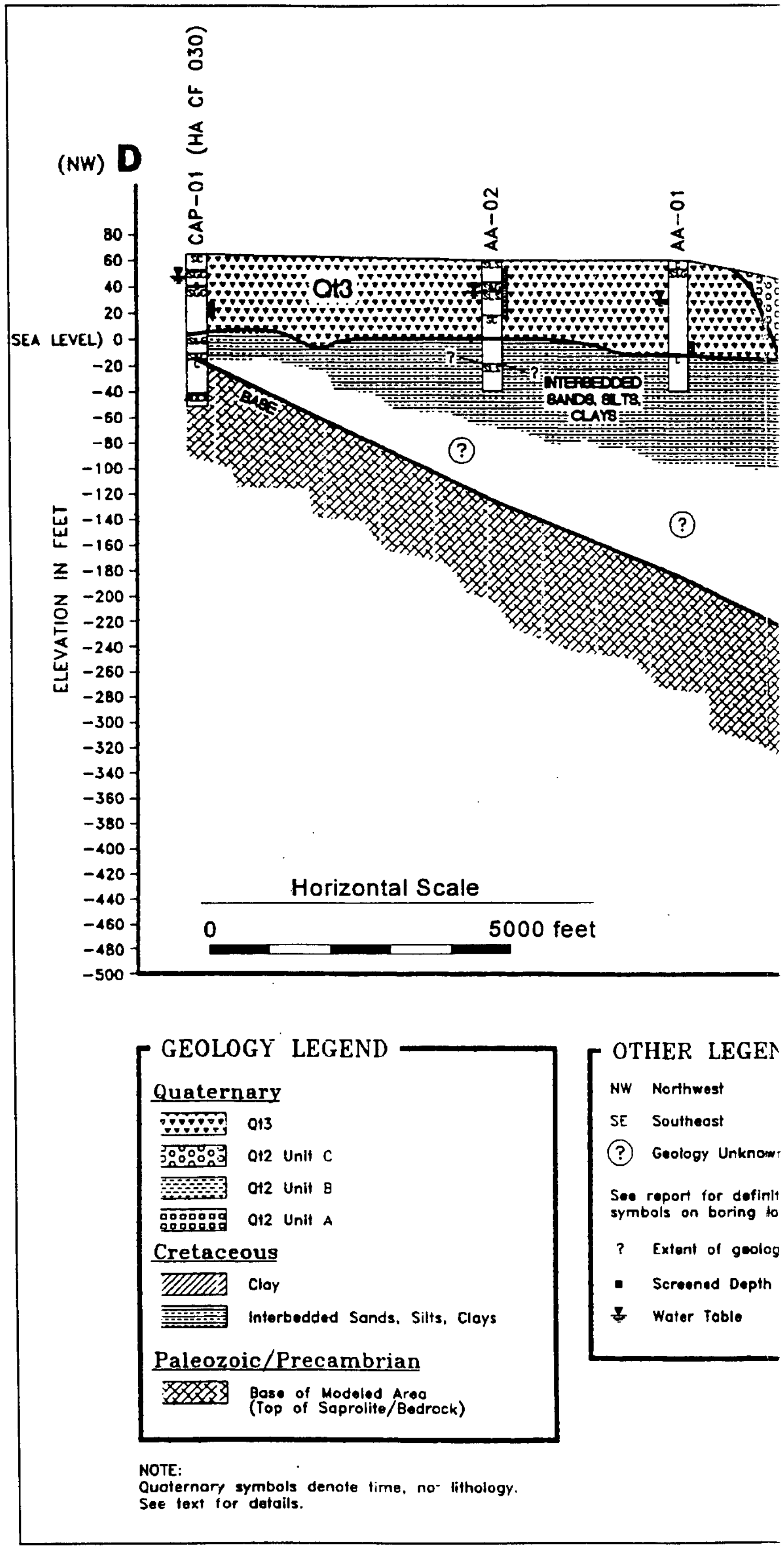
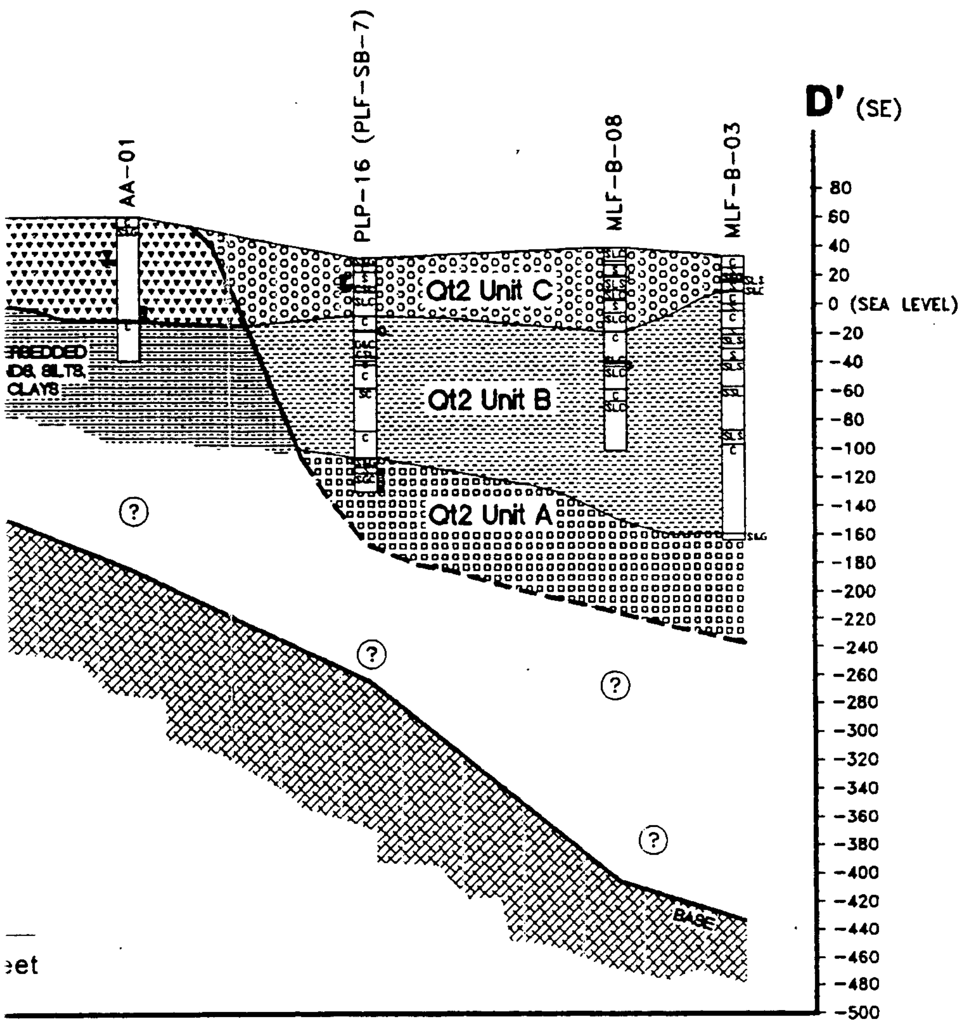


Figure 40. Cross section D-D' (USAEDB 1996a)



OTHER LEGEND

NW Northwest

SE Southeast

(?) Geology Unknown

See report for definition of geologic symbols on boring logs

? Extent of geologic contact unknown

■ Screened Depth

Water Table

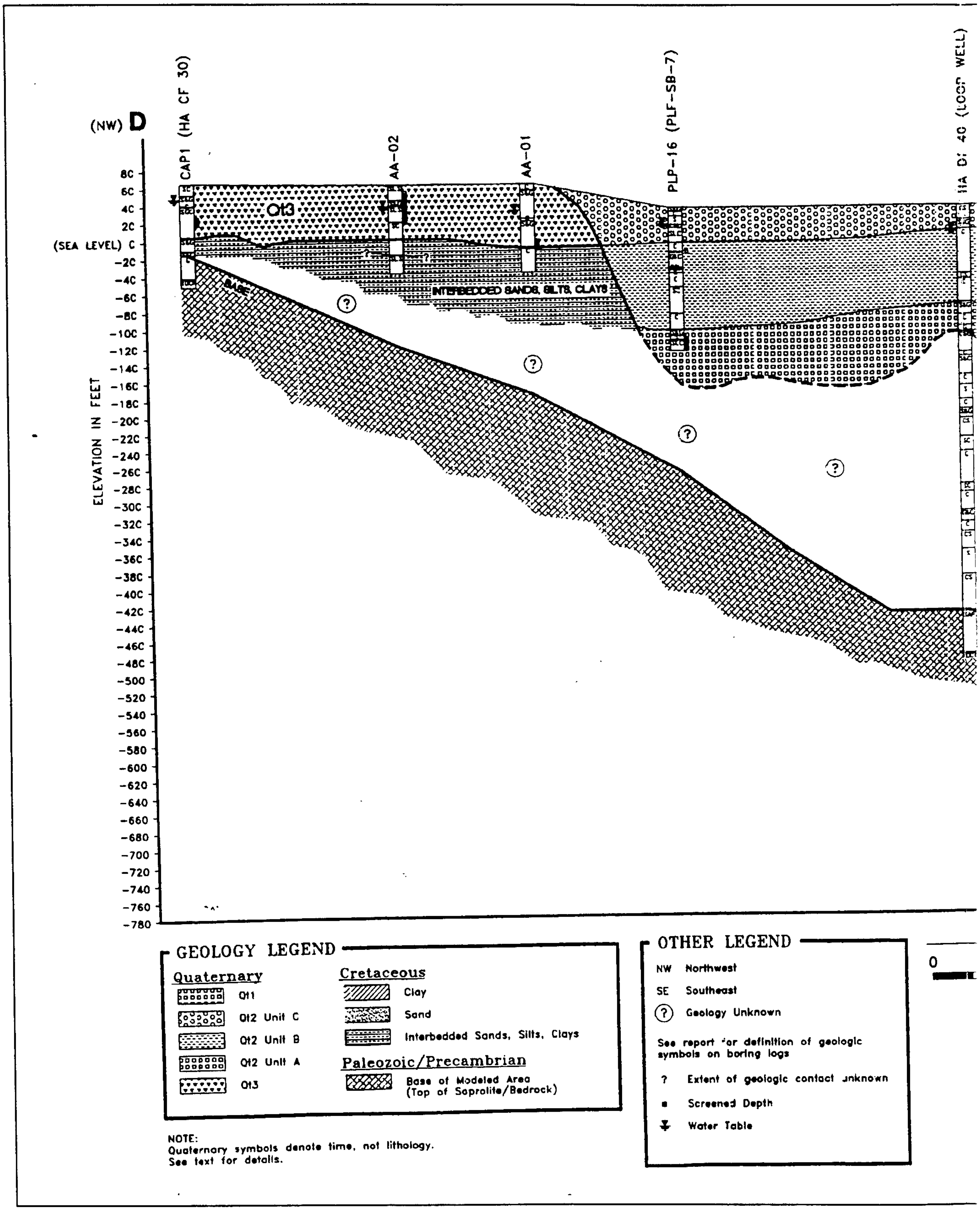
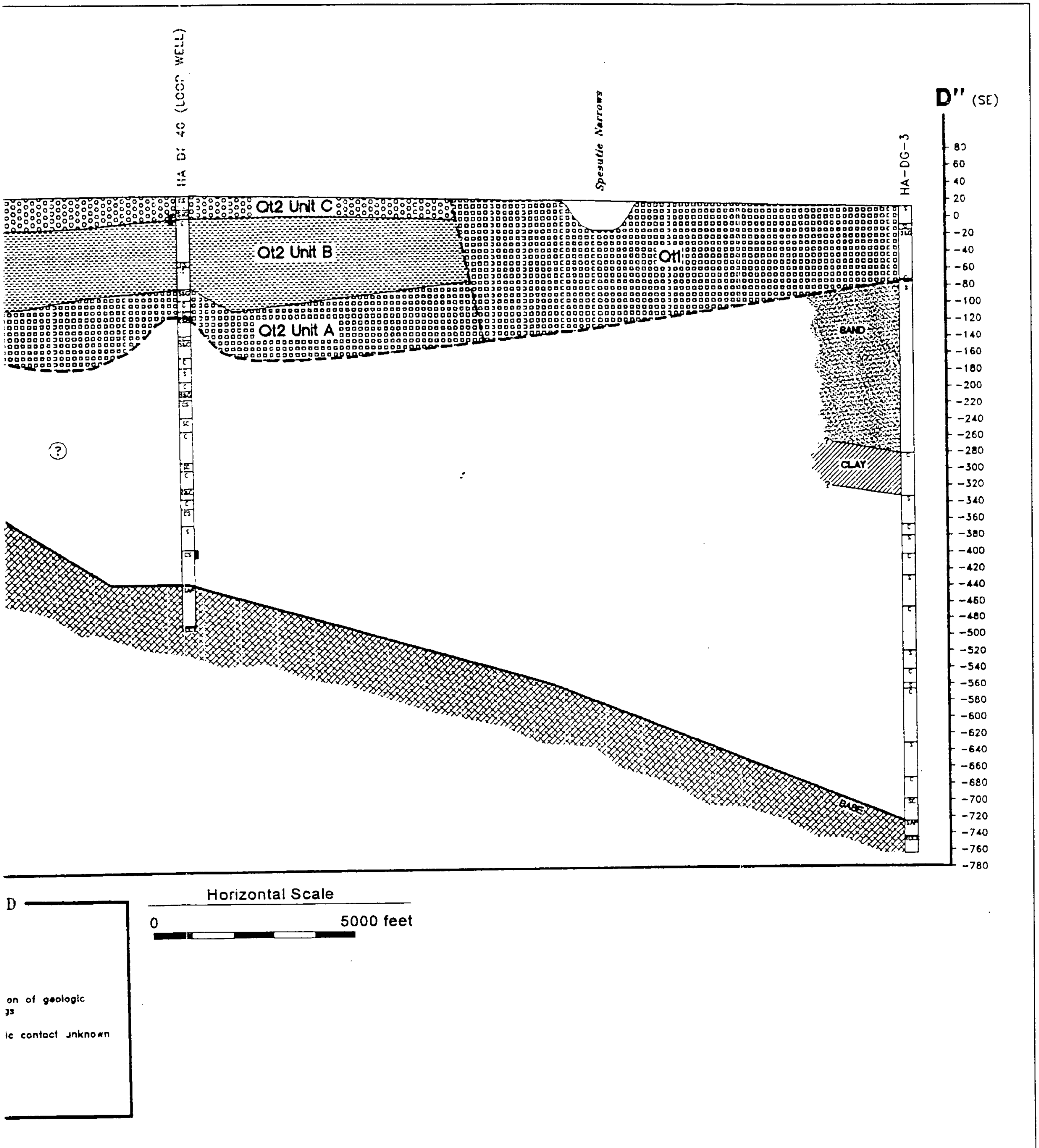


Figure 41. Cross section D-D" (USAEDB 1996)



D'' (SE)
HA DI 40 (LOOP WELL)
Spesutie Narrows
HA-DG-3
Qt2 Unit C
Qt2 Unit B
Qt2 Unit A
Qt1
SAND
CLAY
BASE
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
-320
-340
-360
-380
-400
-420
-440
-460
-480
-500
-520
-540
-560
-580
-600
-620
-640
-660
-680
-700
-720
-740
-760
-780
D
Horizontal Scale
0
5000 feet
on of geologic
gs
ic contact unknown

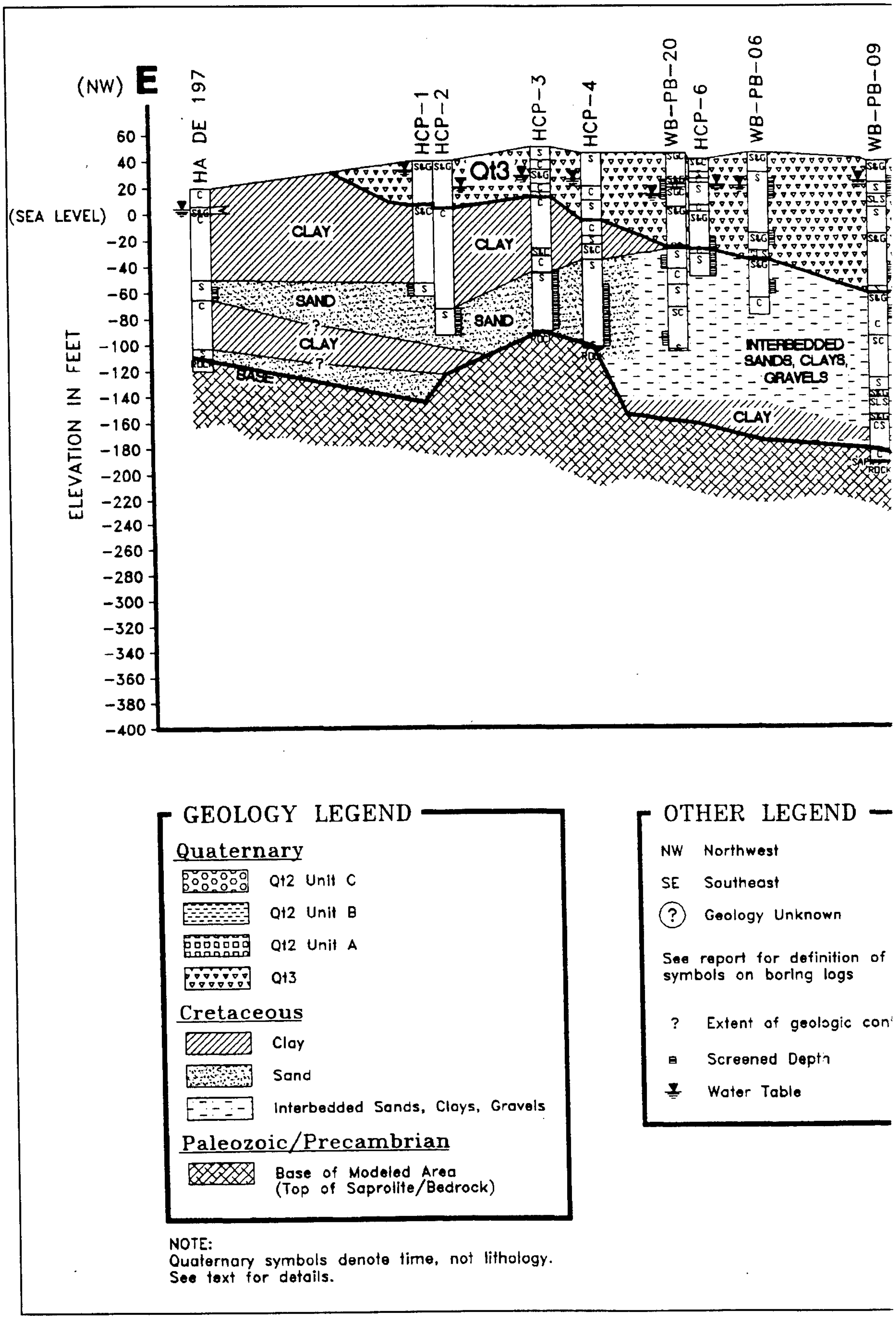
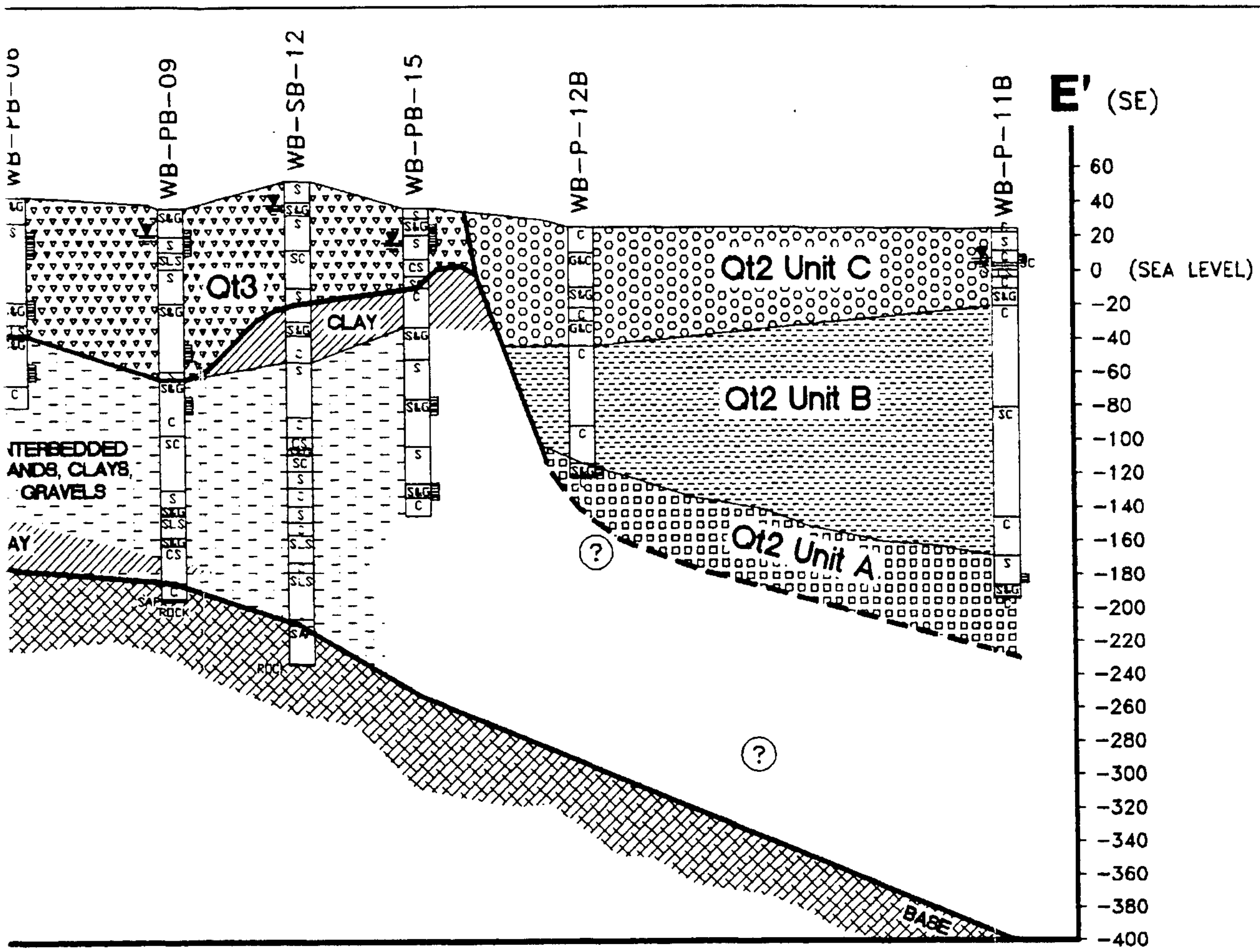


Figure 42. Cross section E-E' (USAEDB 1996a)



LEGEND

est

ast

y Unknown

for definition of geologic boring logs

of geologic contact unknown

ned Depth

Table

Horizontal Scale

0 5000 feet

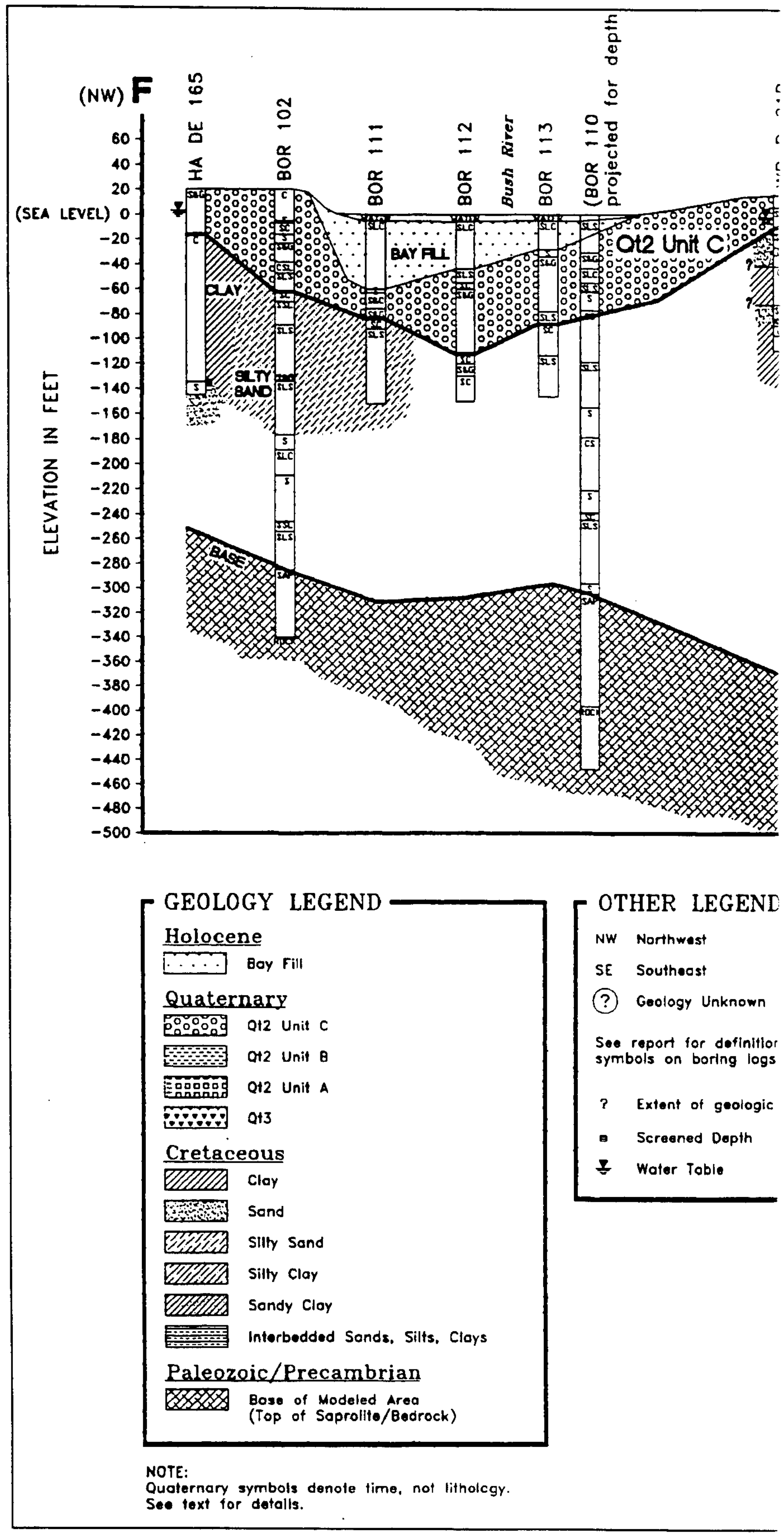
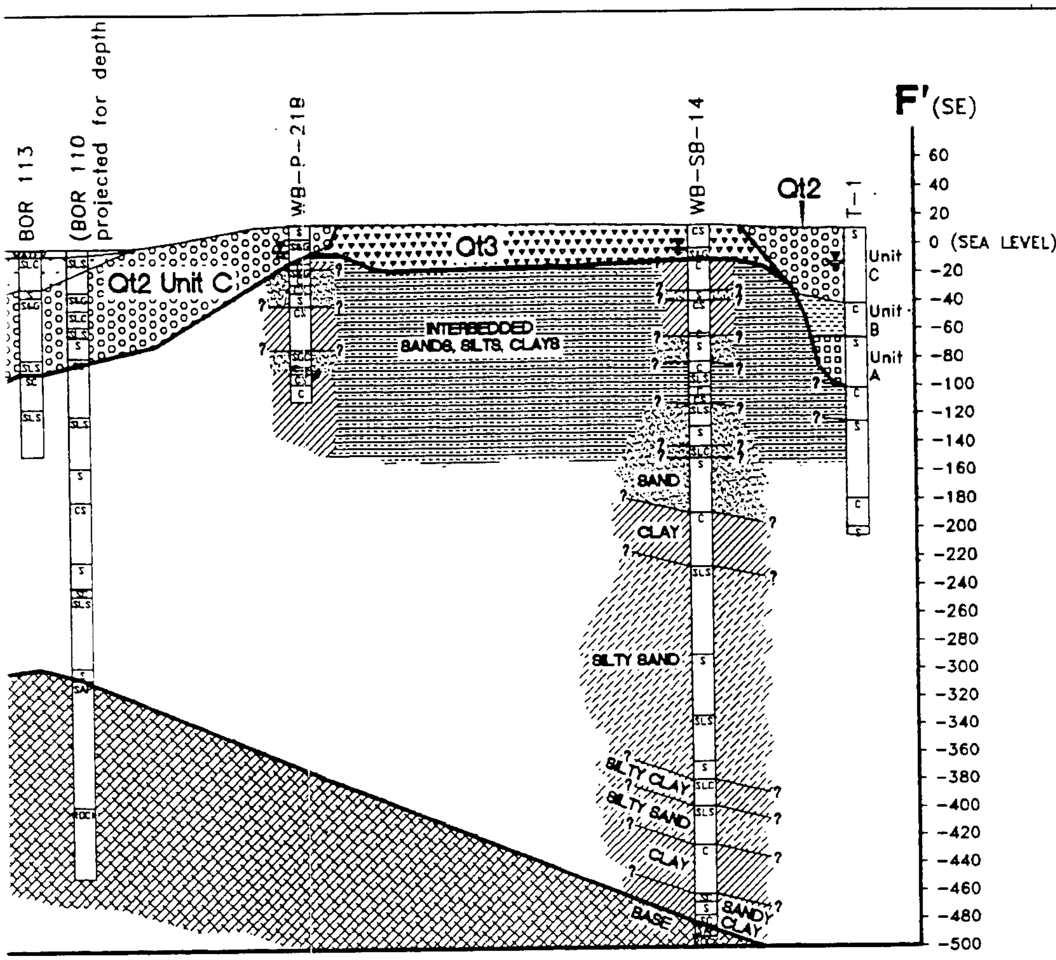
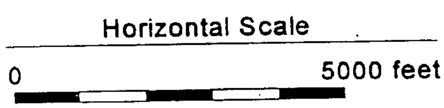


Figure 43. Cross section F-F' (USAEDB 1996a)





OTHER LEGEND

NW Northwest

SE Southeast

(?) Geology Unknown

See report for definition of geologic symbols on boring logs

? Extent of geologic contact unknown

▪ Screened Depth

$\overline{\nabla}$ Water Table

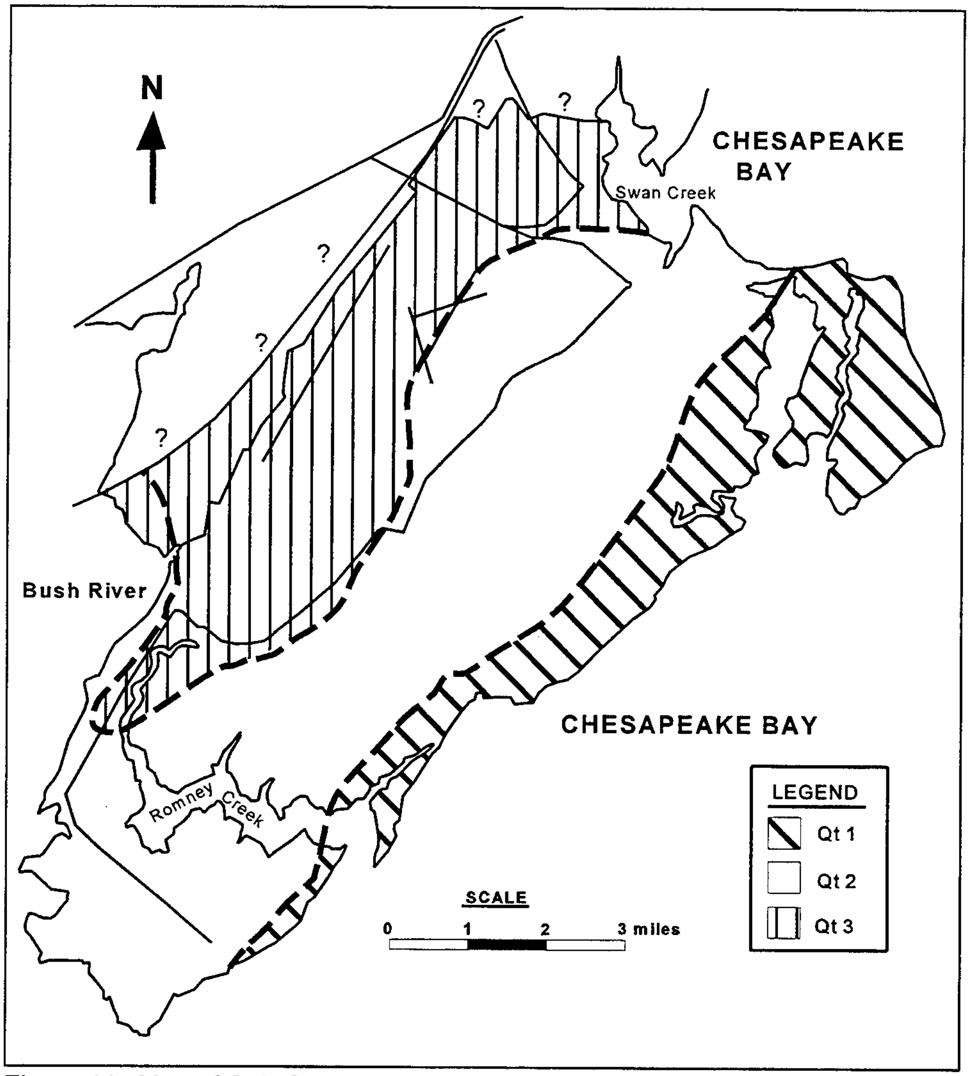


Figure 44. Map of Qt1, Qt2, and Qt3 surfaces on APG-AA (Dunbar et al. 1997)

Susquehanna River system during the Quaternary. These three surfaces are identified as Quaternary terrace 1 (Qt1), Quaternary terrace 2 (Qt2), and Quaternary terrace 3 (Qt3) with the Qt3 surface being the oldest.

Over 500 boring logs (i.e., soil borings, monitoring wells, piezometer, and production wells) were reviewed to determine both the horizontal and vertical extent of the three terraces as well as other subsurface depositional environments and geologic boundaries. Differences in lithology, color, and soil stiffness or hardness were used to separate the Quaternary sediments from the older, Cretaceous deposits. Quaternary sediments characteristic of terrace deposits are usually brown, tan, or orange sands, silts, and clays that grade vertically with depth to darker colors, dark brown, grey, and dark grey. In contrast, the upper part of the Cretaceous sediments has been highly oxidized and weathered to dark orange and red. Variegated red, white, lavender, and grey clays, silts, and sands are common and reflect their greater age and longer weathering.

A contour map of the top of the Cretaceous surface on APG-AA was constructed using the borings on the APG. Cretaceous sediments generally

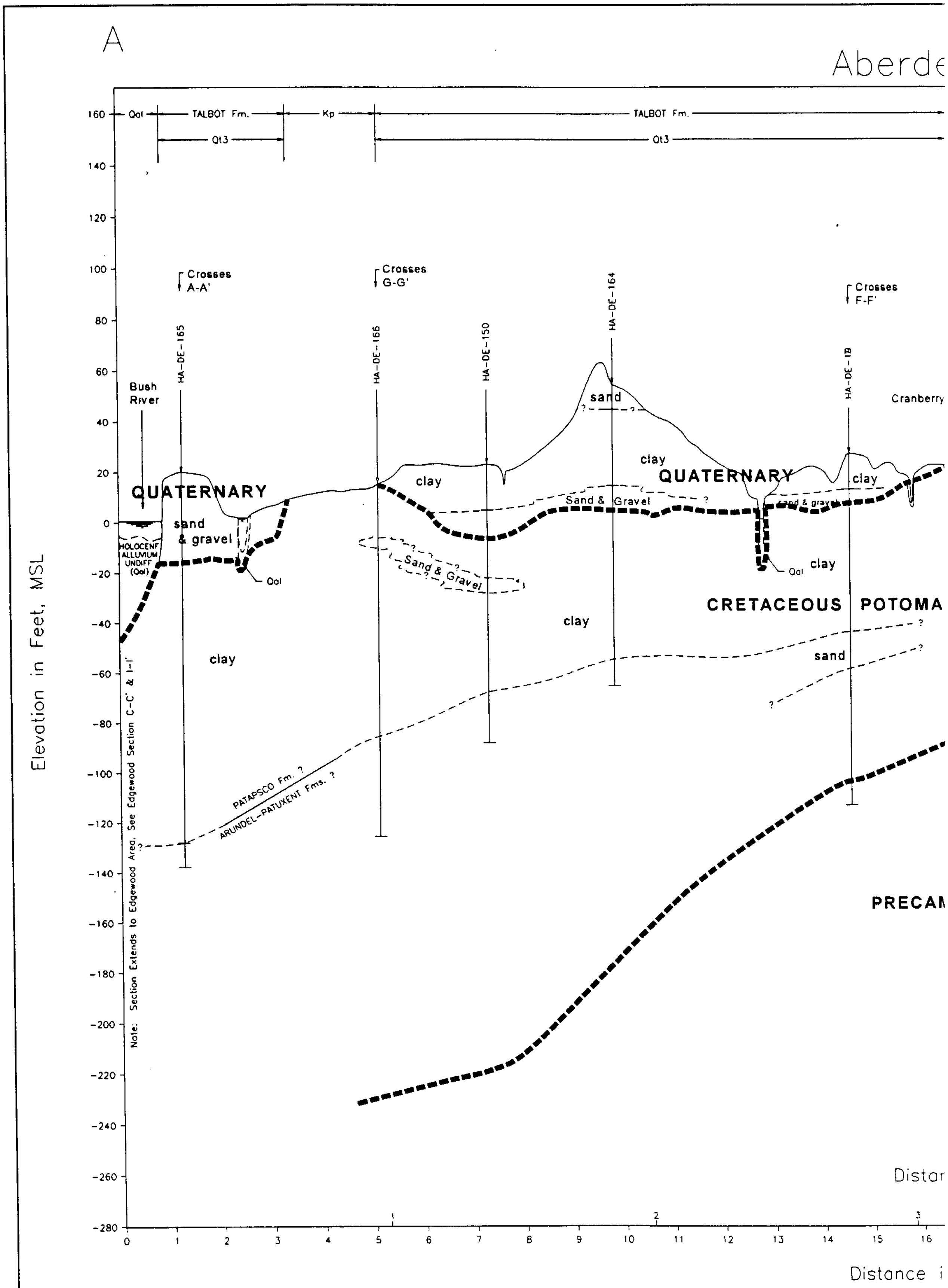
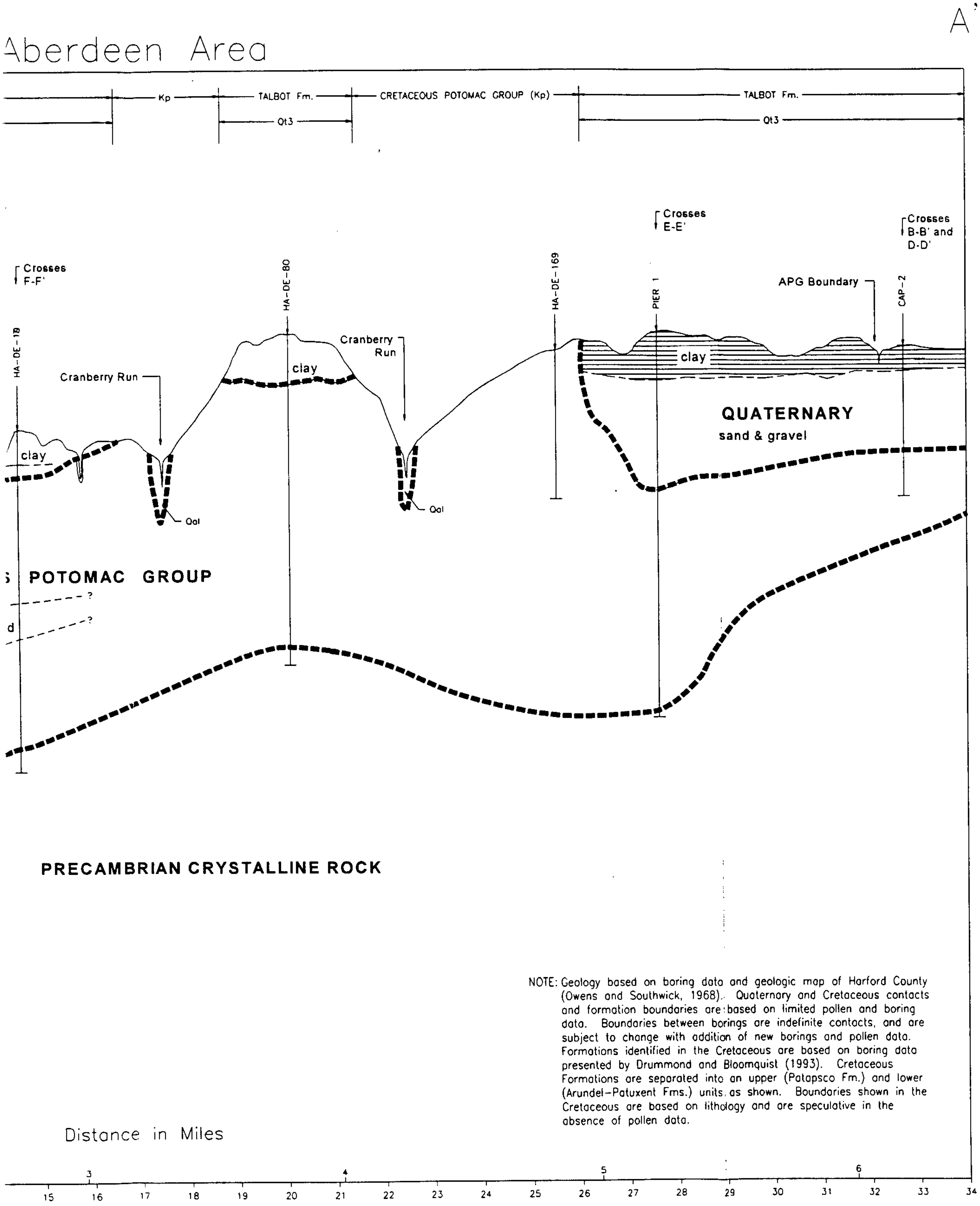


Figure 46. Cross section A-A' (Dunbar et al 1997)

Aberdeen Area



NOTE: Geology based on boring data and geologic map of Harford County (Owens and Southwick, 1968). Quaternary and Cretaceous contacts and formation boundaries are based on limited pollen and boring data. Boundaries between borings are indefinite contacts, and are subject to change with addition of new borings and pollen data. Formations identified in the Cretaceous are based on boring data presented by Drummond and Bloomquist (1993). Cretaceous Formations are separated into an upper (Patapsco Fm.) and lower (Arundel-Patuxent Fms.) units as shown. Boundaries shown in the Cretaceous are based on lithology and are speculative in the absence of pollen data.

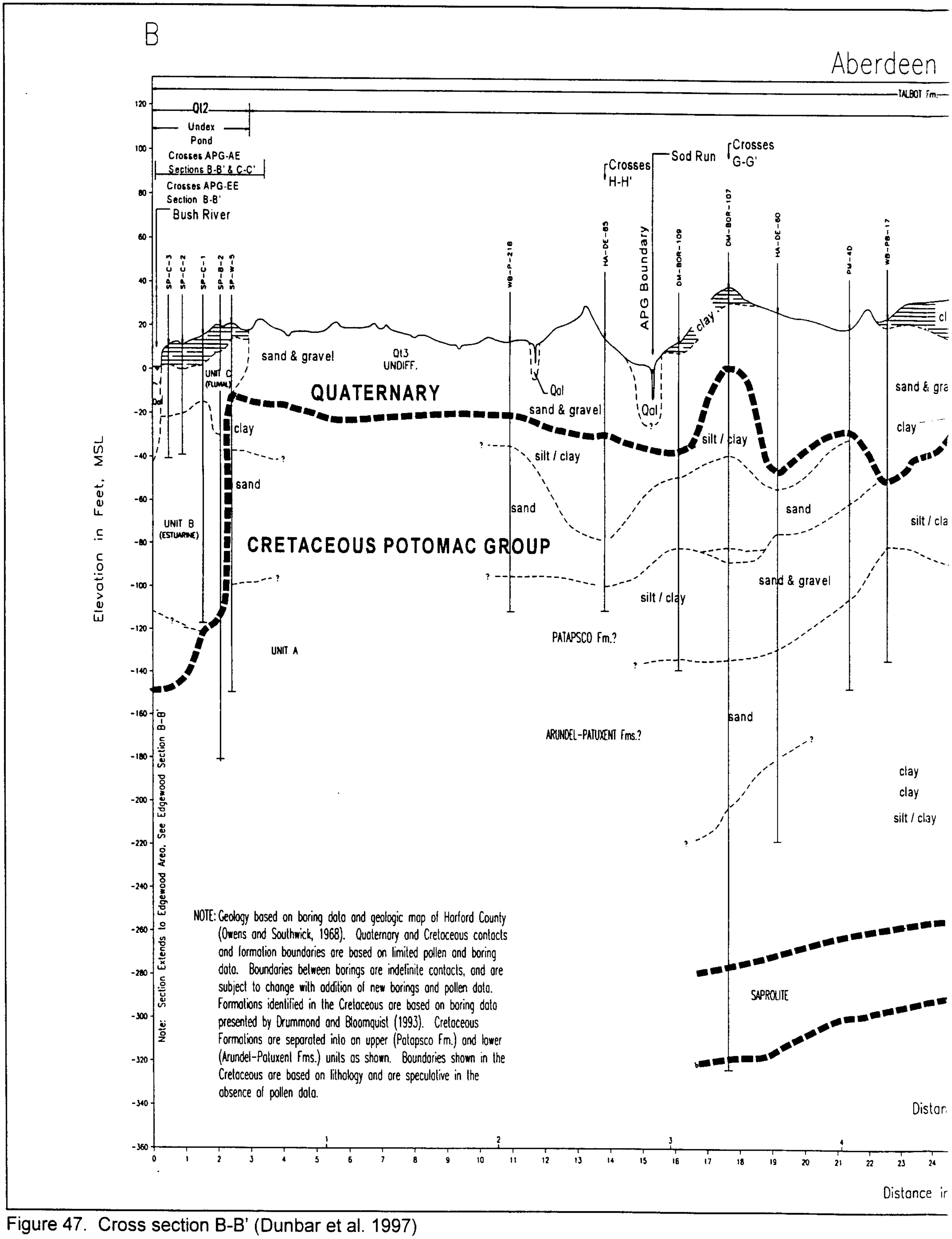
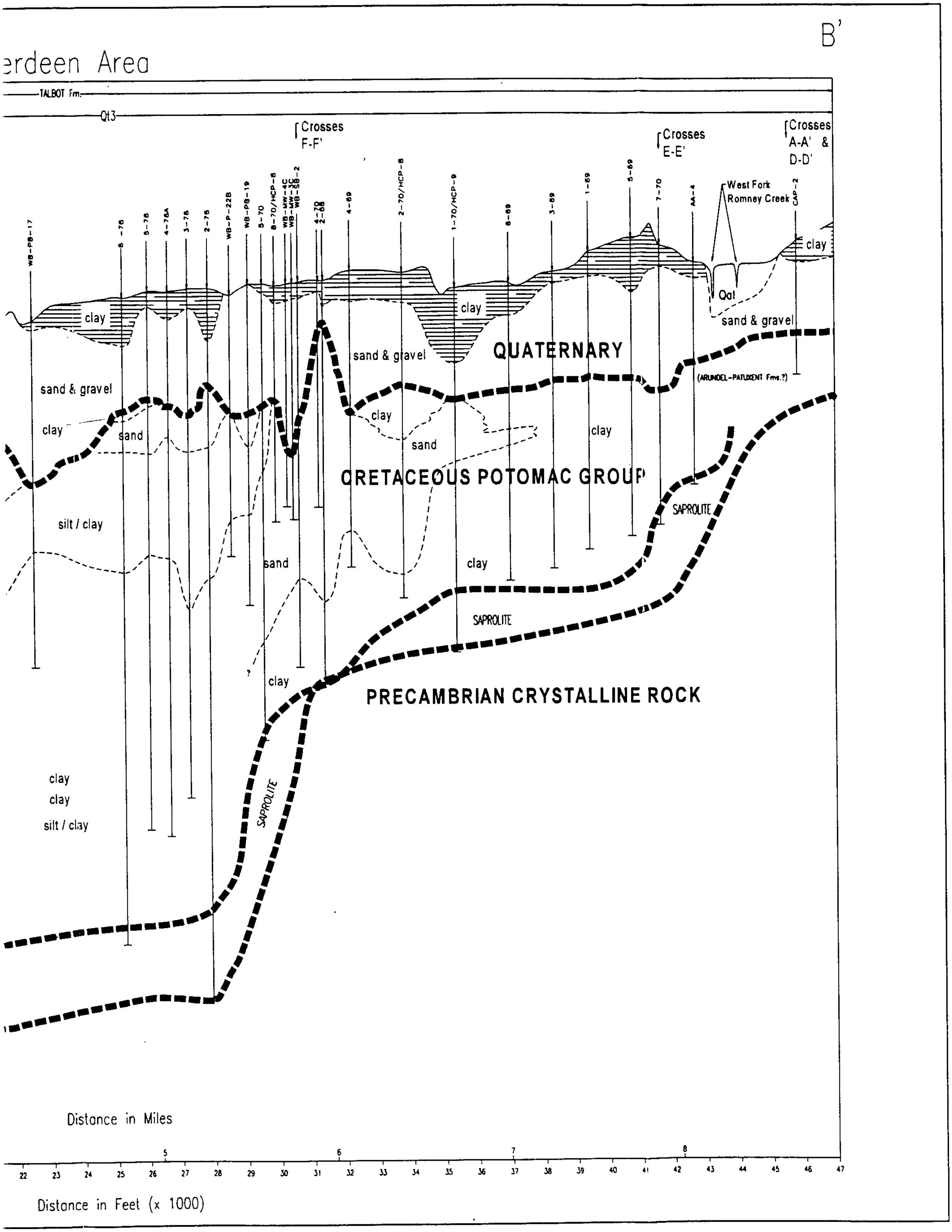


Figure 47. Cross section B-B' (Dunbar et al. 1997)


B'
erdeen Area
TALBOT Fm.
Q13
Crosses F-F'
Crosses E-E'
Crosses A-A' & D-D'
West Fork Romney Creek
clay
sand & gravel
Qal
QUATERNARY
(ARUNDEL-PATUXENT Fms.?)
CRETACEOUS POTOMAC GROUP
silt / clay
sand
SAPROLITE
PRECAMBRIAN CRYSTALLINE ROCK
Distance in Miles
Distance in Feet (x 1000)

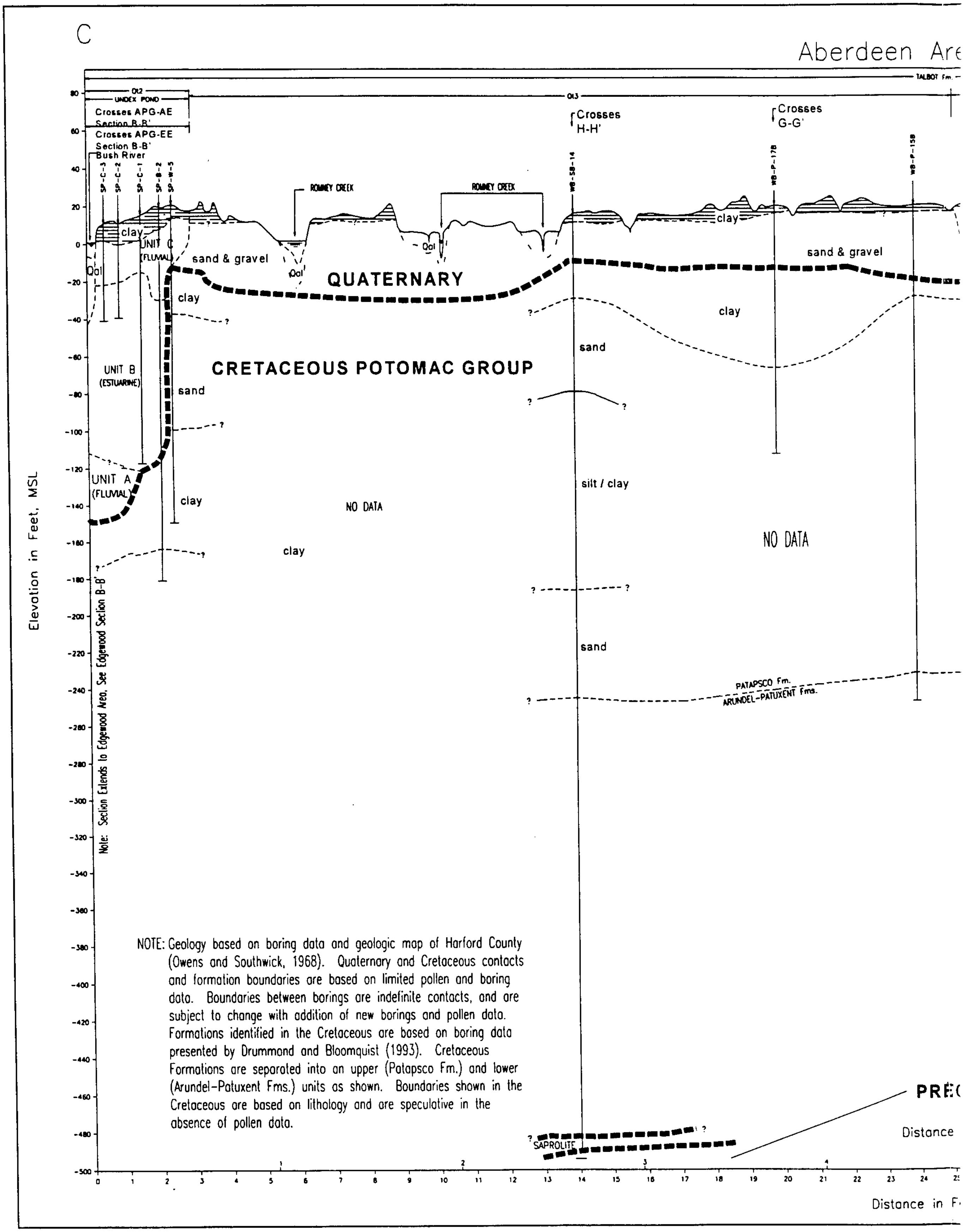
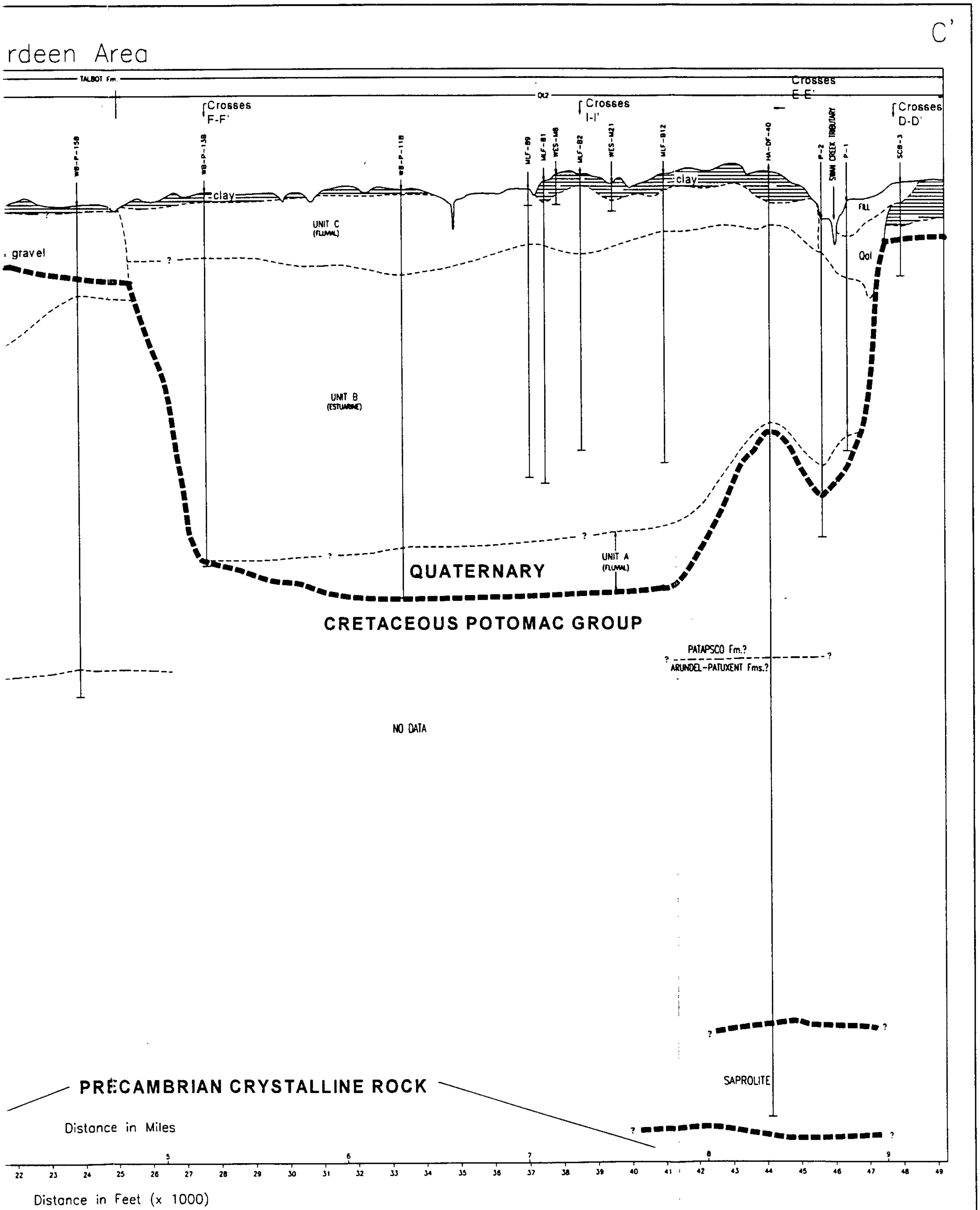


Figure 48. Cross section C-C' (Dunbar et al. 1997)


C'
rdeen Area
TALBOT Fm.
Qt2
Crosses F-F'
Crosses I-I'
Crosses E-E'
Crosses D-D'
WB-P-15B
WB-P-13B
WB-P-11B
MLF-B9
MLF-B1
WES-M8
MLF-B2
WES-M21
MLF-B12
HA-DY-40
P-2
SWAN CREEK TRIBUTARY
P-1
SCB-3
clay
clay
FILL
Qal
gravel
UNIT C (FLUVIAL)
UNIT B (ESTUARINE)
UNIT A (FLUVIAL)
QUATERNARY
CRETACEOUS POTOMAC GROUP
PATAPSCO Fm.?
ARUNDEL-PATUXENT Fms.?
NO DATA
SAPROLITE
PRECAMBRIAN CRYSTALLINE ROCK
Distance in Miles
5
6
7
8
9
22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
Distance in Feet (x 1000)

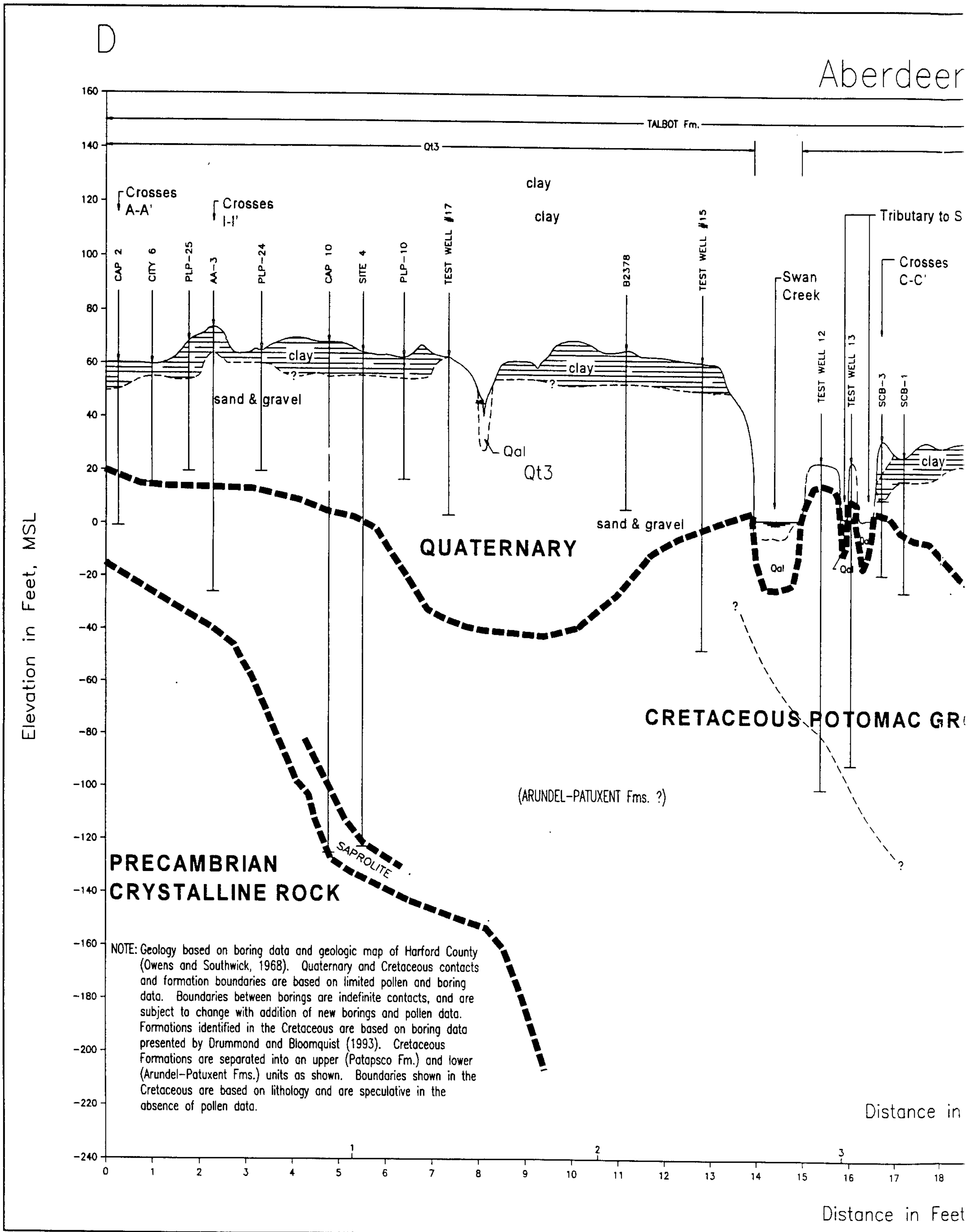
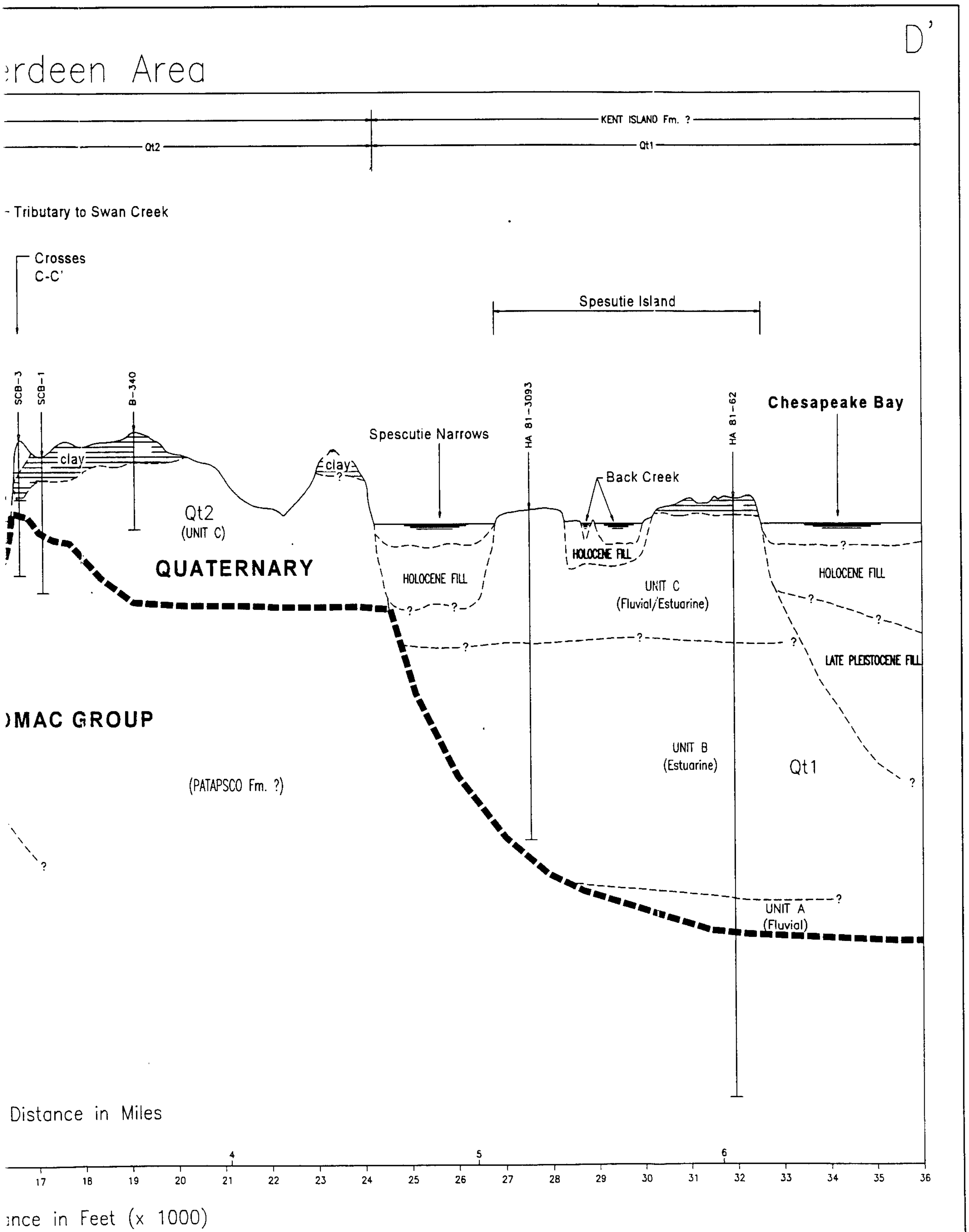


Figure 49. Cross section D-D' (Dunbar et al. 1997)



D'
:rdeen Area
KENT ISLAND Fm. ?
Qt2
Qt1
- Tributary to Swan Creek
Crosses C-C'
Spesutie Island
SCB-3
SCB-1
B-340
HA 81-3093
HA 81-62
Chesapeake Bay
Spescutie Narrows
Back Creek
clay
clay
Qt2
(UNIT C)
QUATERNARY
HOLOCENE FILL
HOLOCENE FILL
HOLOCENE FILL
UNIT C
(Fluvial/Estuarine)
LATE PLEISTOCENE FILL
)MAC GROUP
UNIT B
(Estuarine)
Qt1
(PATAPSCO Fm. ?)
UNIT A
(Fluvial)
Distance in Miles
4
5
6
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
:nce in Feet (x 1000)

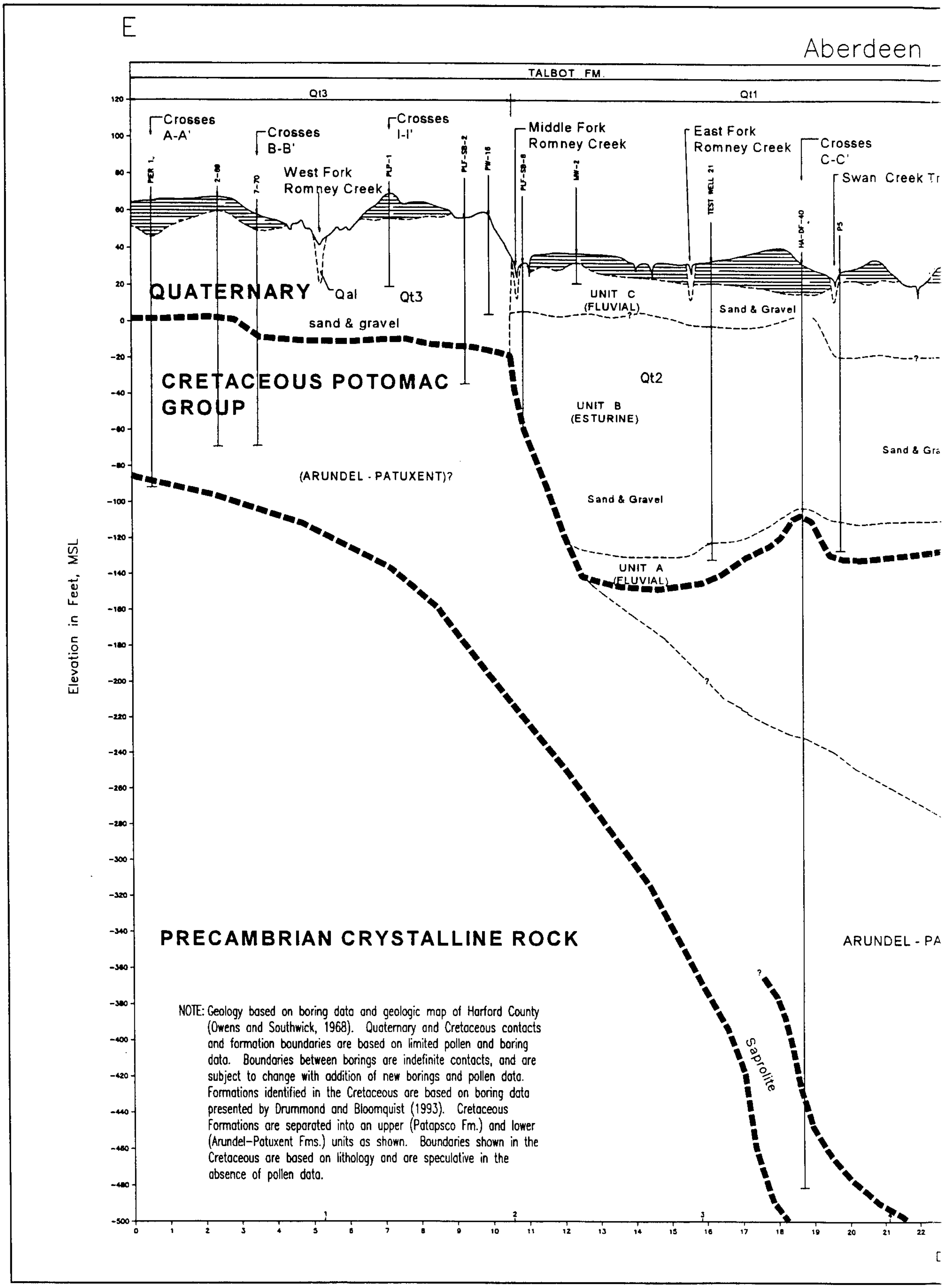
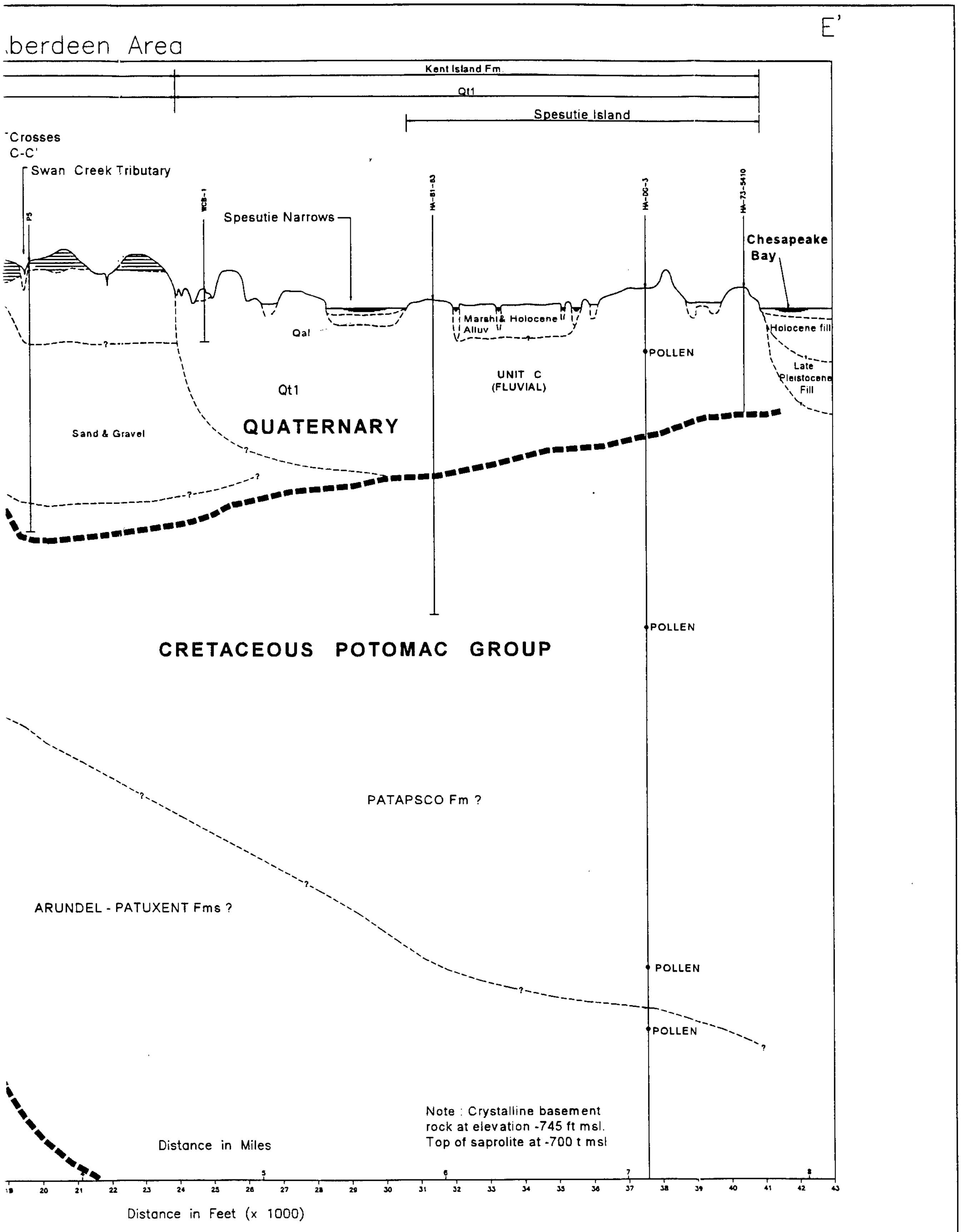


Figure 50. Cross section E-E' (Dunbar et al. 1997)



E'
.berdeen Area
Kent Island Fm.
Qt1
Spesutie Island
Crosses
C-C'
Swan Creek Tributary
P5
WCB-1
Spesutie Narrows
Chesapeake
Bay
Marsh & Holocene
Alluv
Qal
Holocene fill
POLLEN
Late
Pleistocene
Fill
UNIT C
(FLUVIAL)
Qt1
Sand & Gravel
QUATERNARY
CRETACEOUS POTOMAC GROUP
POLLEN
PATAPSCO Fm ?
ARUNDEL - PATUXENT Fms ?
POLLEN
POLLEN
Note : Crystalline basement
rock at elevation -745 ft msl.
Top of saprolite at -700 t msl
Distance in Miles
Distance in Feet (x 1000)

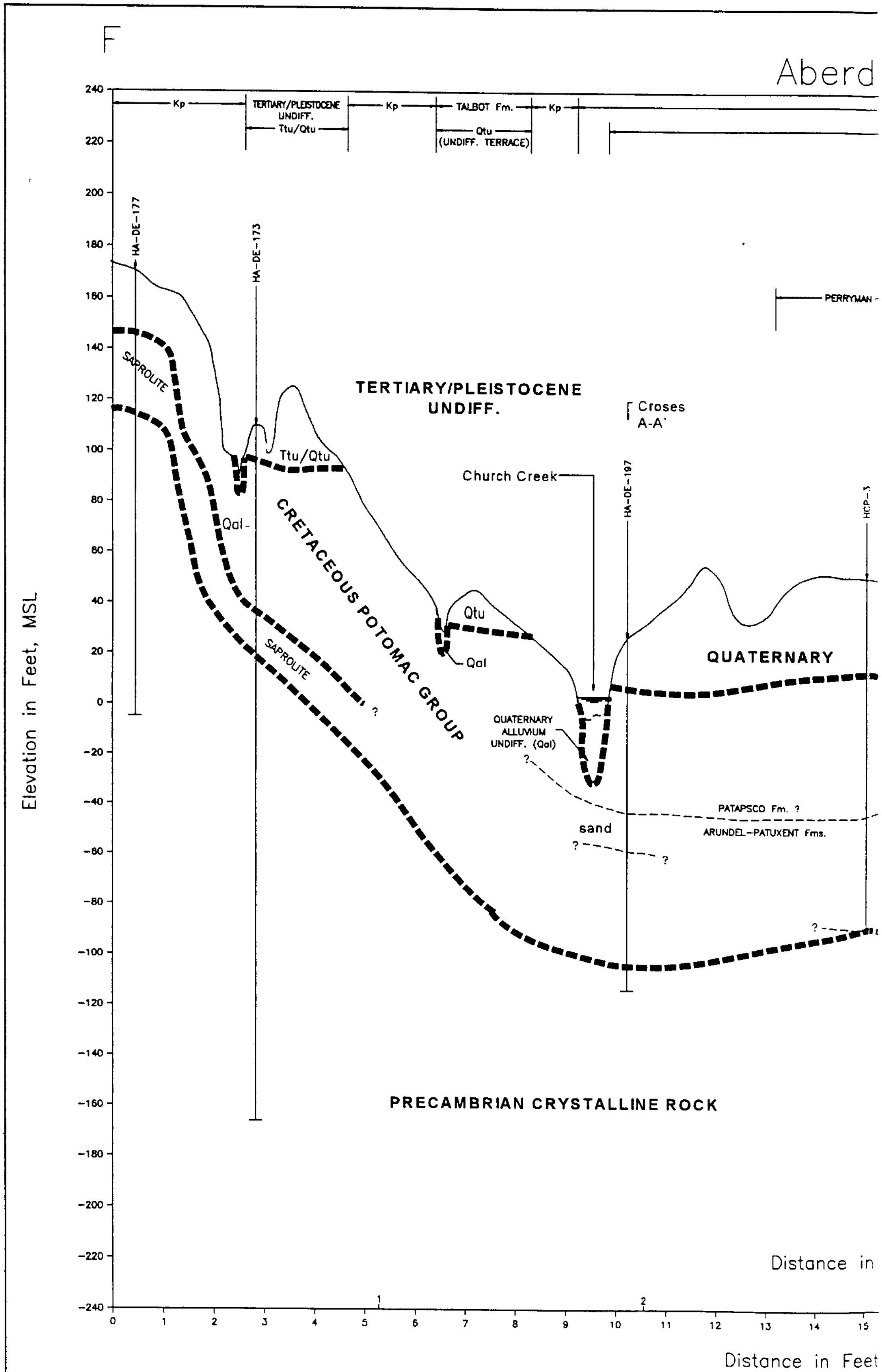
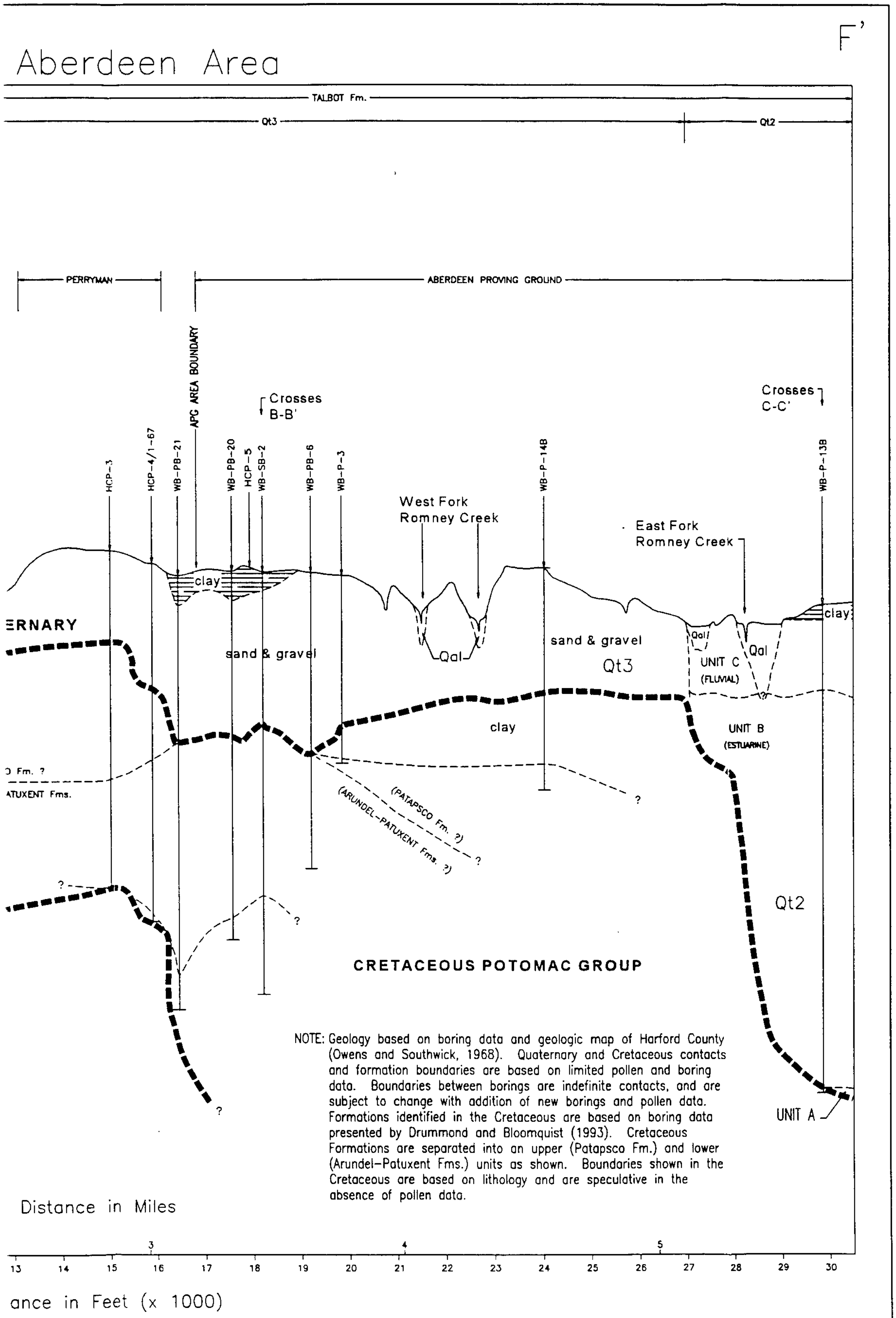


Figure 51. Cross section F-F' (Dunbar et al. 1997)



F'
Aberdeen Area
TALBOT Fm.
Qt3
Qt2
PERRYMAN
ABERDEEN PROVING GROUND
APG AREA BOUNDARY
Crosses B-B'
Crosses C-C'
HCP-3
HCP-4/1-67
WB-PB-21
WB-PB-20
HCP-5
WB-SB-2
WB-PB-6
WB-P-3
WB-P-14B
WB-P-13B
West Fork Romney Creek
East Fork Romney Creek
clay
sand & gravel
Qal
Qt3
UNIT C (FLUVIAL)
UNIT B (ESTUARINE)
ERNARY
D Fm. ?
ATUXENT Fms.
(PATAPSCO Fm. ?)
(ARUNDEL-PATUXENT Fms. ?)
Qt2
CRETACEOUS POTOMAC GROUP
UNIT A
NOTE: Geology based on boring data and geologic map of Harford County (Owens and Southwick, 1968). Quaternary and Cretaceous contacts and formation boundaries are based on limited pollen and boring data. Boundaries between borings are indefinite contacts, and are subject to change with addition of new borings and pollen data. Formations identified in the Cretaceous are based on boring data presented by Drummond and Bloomquist (1993). Cretaceous Formations are separated into an upper (Patapsco Fm.) and lower (Arundel-Patuxent Fms.) units as shown. Boundaries shown in the Cretaceous are based on lithology and are speculative in the absence of pollen data.
Distance in Miles
3
4
5
13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
ance in Feet (x 1000)

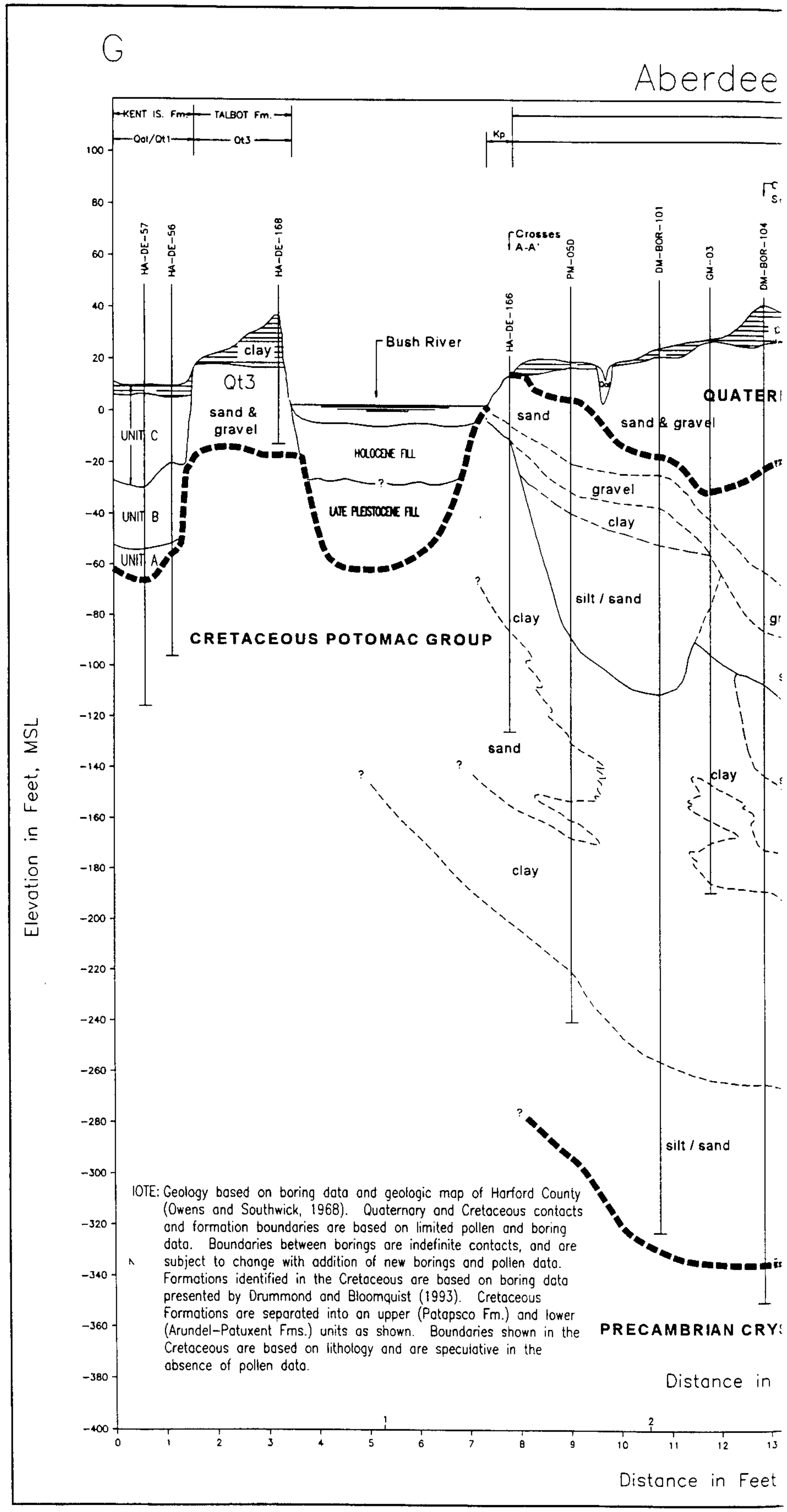
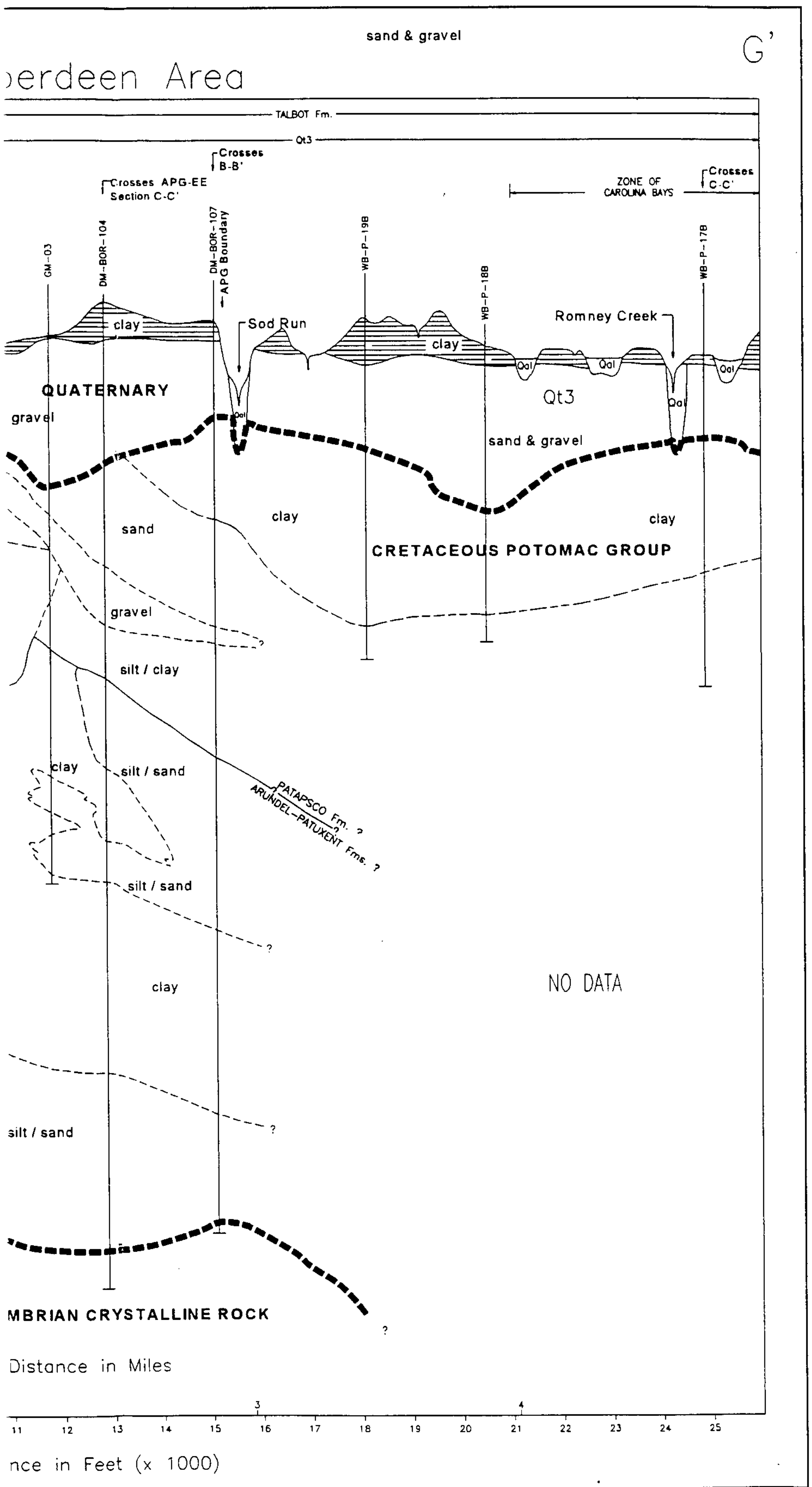


Figure 52. Cross section G-G' (Dunbar et al. 1997)



sand & gravel
G'
)erdeen Area
TALBOT Fm.
Qt3
Crosses B-B'
Crosses APG-EE Section C-C'
ZONE OF CAROLINA BAYS
Crosses C-C'
GM-03
DM-BOR-104
DM-BOR-107
APG Boundary
WB-P-19B
WB-P-18B
WB-P-17B
clay
Sod Run
Romney Creek
Qal
QUATERNARY
Qt3
gravel
sand & gravel
sand
clay
CRETACEOUS POTOMAC GROUP
gravel
silt / clay
clay
silt / sand
PATAPSCO Fm.
ARUNDEL-PATUXENT Fms.
silt / sand
clay
NO DATA
silt / sand
MBRIAN CRYSTALLINE ROCK
Distance in Miles
3
4
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
nce in Feet (x 1000)

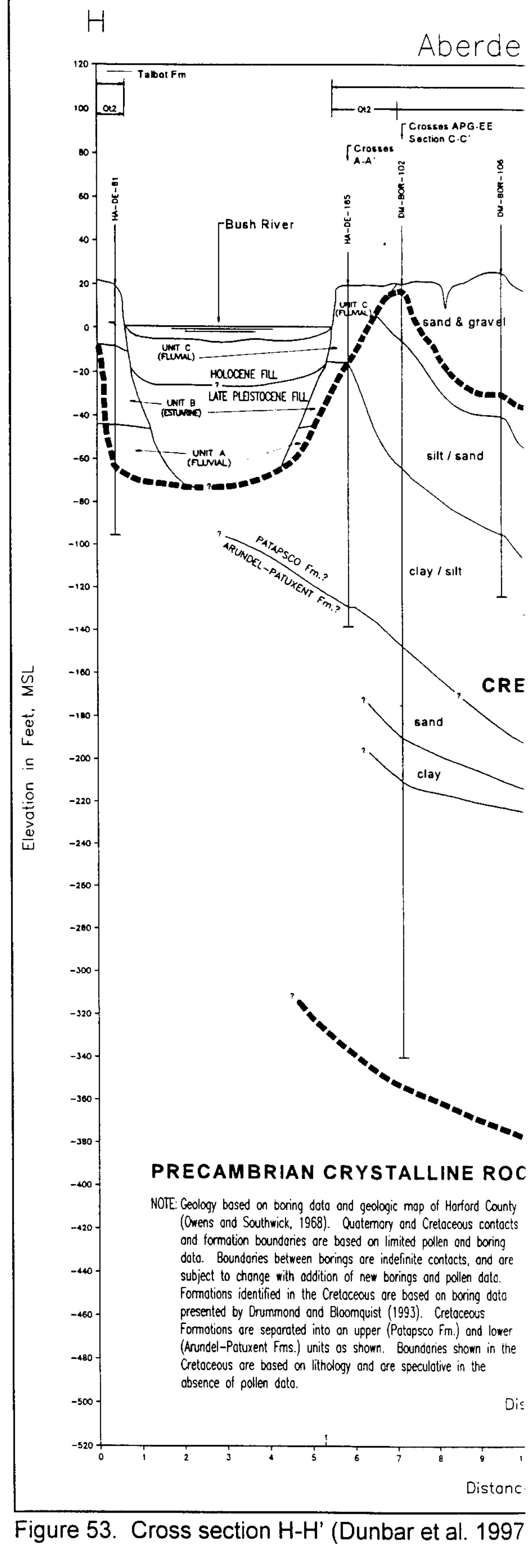
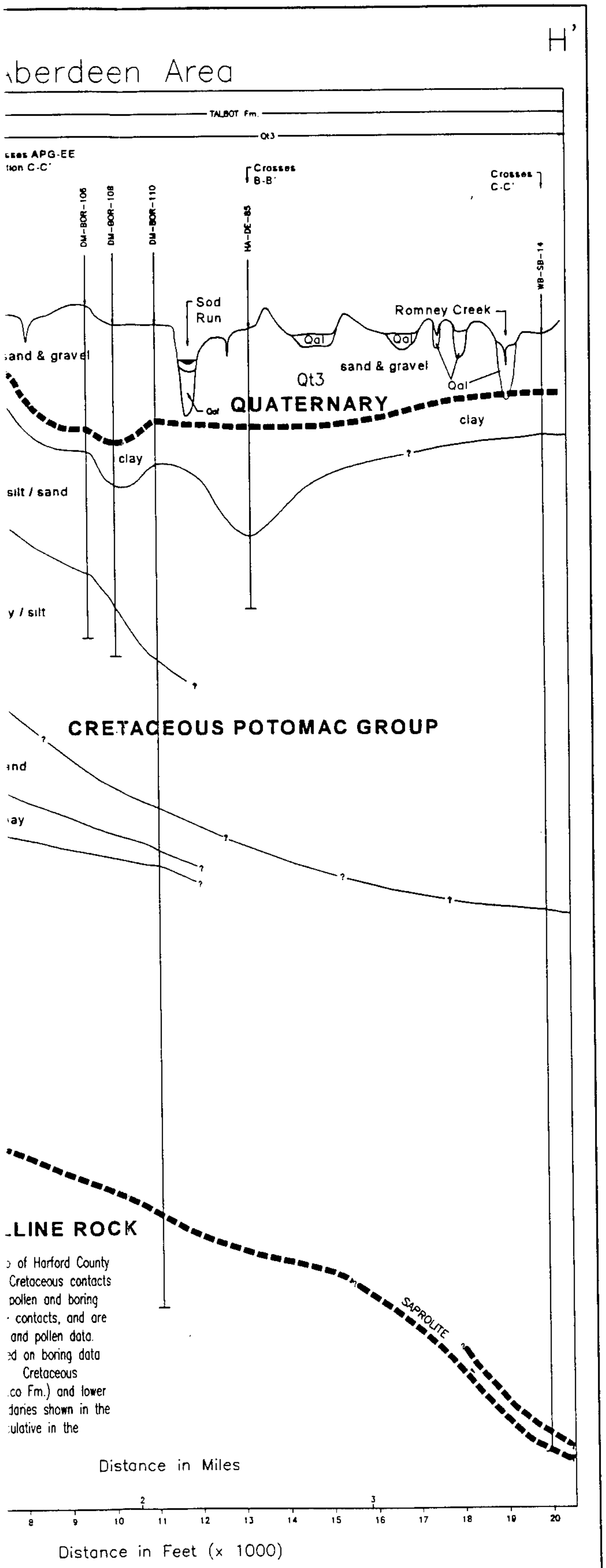


Figure 53. Cross section H-H' (Dunbar et al. 1997


H'
berdeen Area
TALBOT Fm.
Qt3
Crosses B-B'
Crosses C-C'
DM-BOR-106
DM-BOR-108
DM-BOR-110
HA-DE-85
WB-SB-14
Sod Run
Romney Creek
Qal
sand & gravel
Qt3
QUATERNARY
clay
silt / sand
y / silt
CRETACEOUS POTOMAC GROUP
LINE ROCK
SAPROLITE
of Harford County
Cretaceous contacts
pollen and boring
contacts, and are
and pollen data.
on boring data
Cretaceous
co Fm.) and lower
daries shown in the
ulative in the
Distance in Miles
2
3
8
9
10
11
12
13
14
15
16
17
18
19
20
Distance in Feet (x 1000)

et al. 1997)

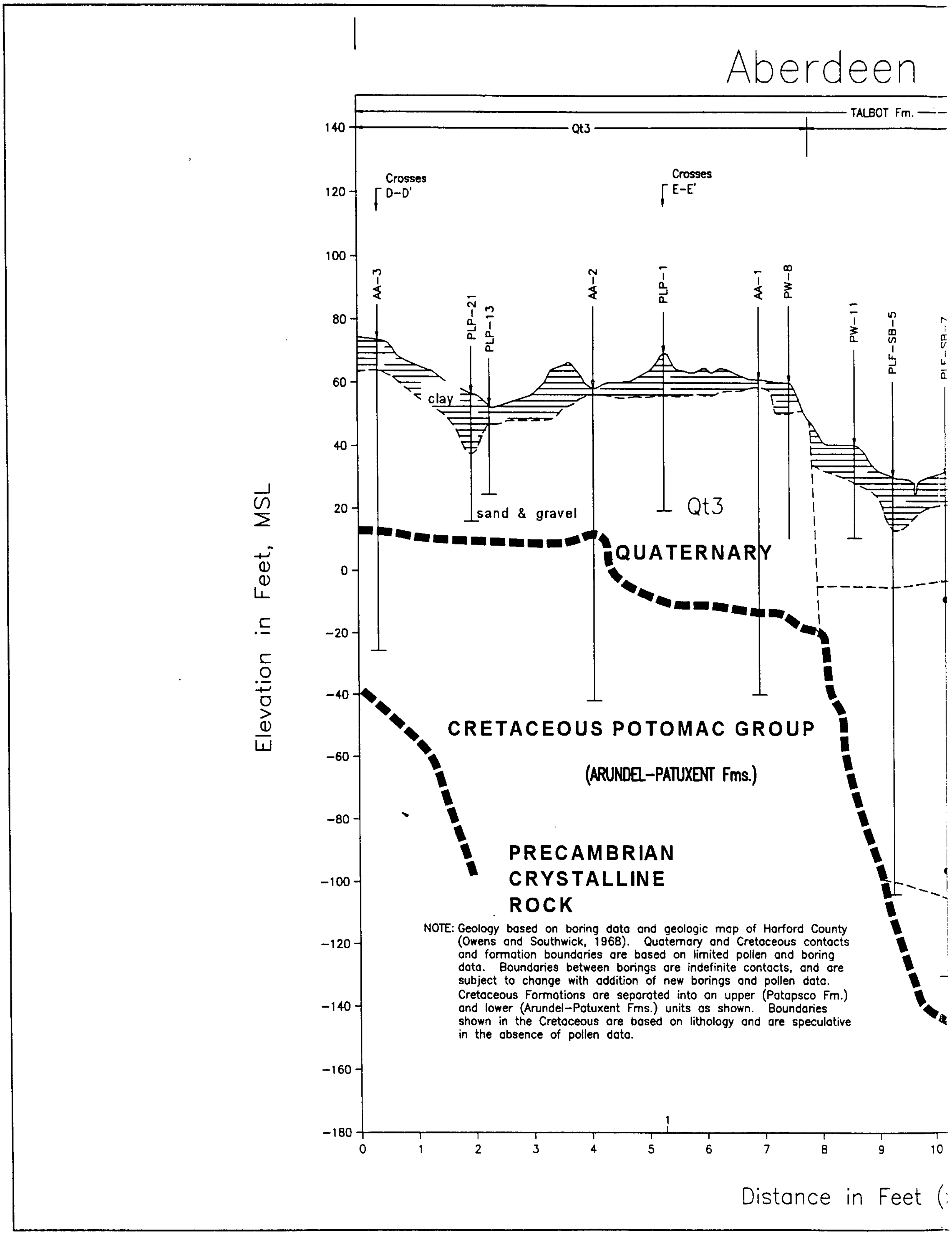
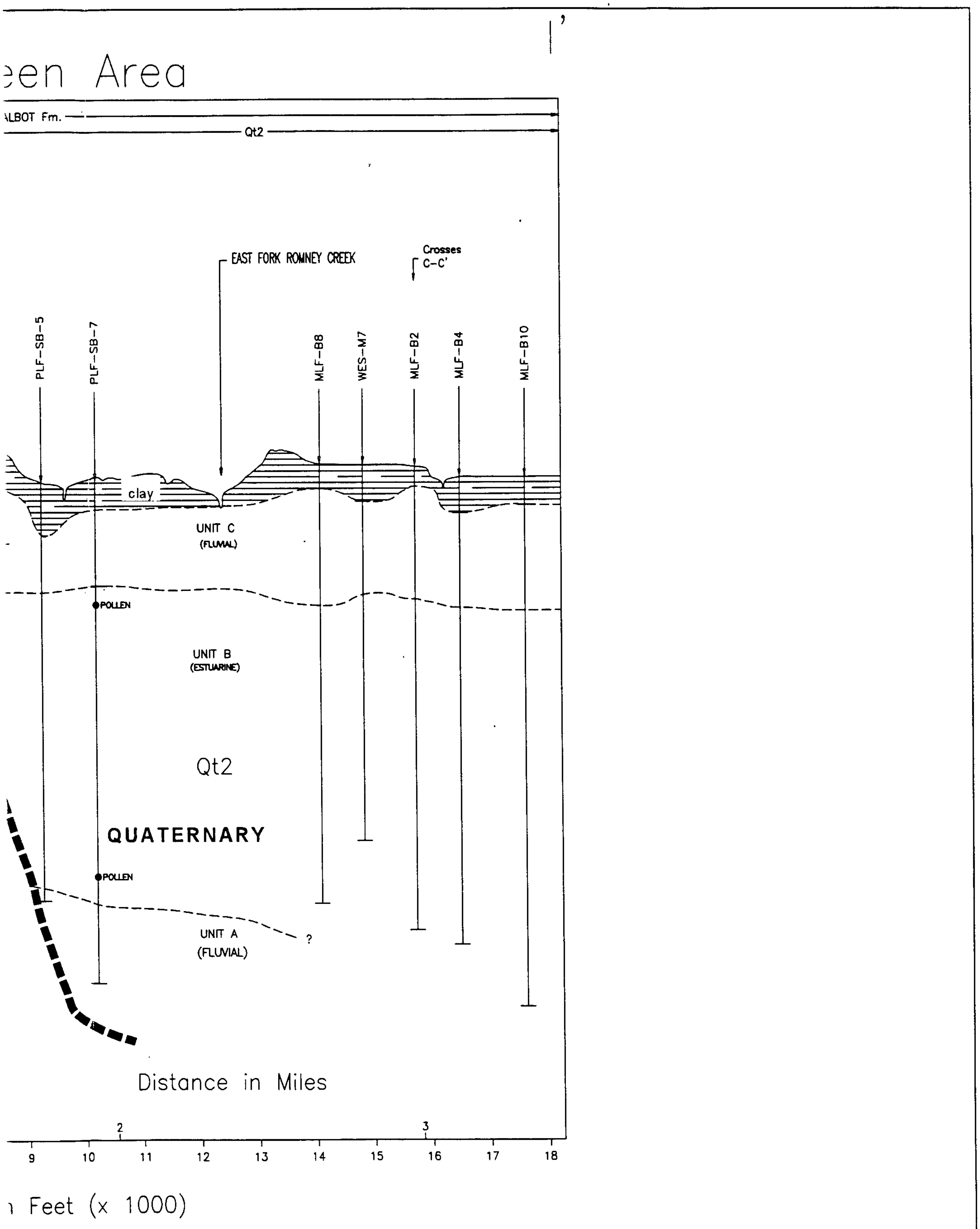


Figure 54. Cross section I-I' (Dunbar et al. 1997)



ɜen Area
ALBOT Fm.
Qt2
EAST FORK ROMNEY CREEK
Crosses C–C'
PLF–SB–5
PLF–SB–7
MLF–B8
WES–M7
MLF–B2
MLF–B4
MLF–B10
clay
UNIT C
(FLUVIAL)
POLLEN
UNIT B
(ESTUARINE)
Qt2
QUATERNARY
POLLEN
UNIT A
(FLUVIAL)
?
Distance in Miles
2
3
9
10
11
12
13
14
15
16
17
18
ı Feet (x 1000)

This Page Intentionaly
Left Blank

associated with the Qt2 surface indicates a Middle Pleistocene age of perhaps 80,000 to 100,000 years before present for this stratigraphic sequence. This age corresponds to the Sangamon interglacial period which was at a higher sea level than the present. It is estimated that the higher terrace sequence (Qt3) is perhaps Early Pleistocene (or Tertiary) in age, while the lower terrace unit is Late Pleistocene in age.

An understanding of the geomorphology at the APG-AA will aid the current groundwater modeling efforts. The study by Dunbar et al (1997) indicates the sediments beneath the APG-AA are horizontally discontinuous units. This will have a definite effect on the interpretations of the movement of groundwater.

Hydrology

Aquifer characteristics and permeabilities

Measured values of aquifer permeability from slug tests at APG-AA are limited to monitor wells screened from the water table to 200 ft in depth. The water table wells, which are less than 100 ft deep, are screened in the Qt3 and Qt2 Unit C terraces. Deeper wells, which are generally about 140 to 160 ft in depth, are screened in the Qt2 Unit B terrace at MLF and in the top of the Cretaceous in the Western Boundary Area. An aquifer pump test was conducted on the PAAF1 and PAAF2 wells. The results from the slug tests and pump test are presented in Table 5.

Table 5
Measured Aquifer Conductivity Values on APG-AA

Location on APG-AA	Name	Conductivity, ft/day	Aquifer
Western Boundary Area	WB-MW-01B	6.74e+01	Qt3
	WB-MW-02B	1.40e+01	Qt3
	WB-MW-03B	1.06e+02	Qt3
	WB-MW-04B	8.37e+01	Qt3
	WB-MW-05A	2.90e+01	Qt3
	WB-MW-06A	4.00e+01	Qt3
	WB-MW-06B	1.24e+01	Qt3
	WB-MW-07A	1.66e+02	Qt3
	WB-MW-07B	1.08e+01	Qt3
	WB-MW-08A	2.02e+00	Qt3
	WB-MW-08B	4.72e+01	Qt3
	WB-MW-09A	7.13e+01	Qt3
	WB-MW-09B	2.29e+01	Qt3
	WB-MW-10A	6.38e+01	Qt3
	WB-MW-10B	1.56e+01	Qt3
	WB-MW-11A	1.96e+01	Qt3
	WB-MW-11B	3.71e+02	Qt3
	WB-MW-12A	6.05e+00	Qt3
	WB-MW-12B	1.44e+00	Qt3
	WB-MW-13A	1.31e+02	Qt3
	WB-MW-13B	1.57e+01	Qt3
	WB-MW-14A	8.64e+01	Qt3
			(Continued)

Table 5 (Concluded)			
Location on APG-AA	Name	Conductivity, ft/day	Aquifer
Western Boundary Area	WB-MW-16A	3.70e+01	Qt3
	WB-MW-17A	7.96e+01	Qt3
	WB-MW-18A	1.25e+01	Qt3
	WB-MW-19A	2.65e+01	Qt3
	WB-MW-19B	1.55e+02	Qt3
	WB-MW-20A	7.72e+01	Qt3
	WB-MW-21A	1.44e+01	Qt3
	WB-MW-22A	4.09e+01	Qt3
	WB-MW-15A	2.30e+00	Qt2 Unit C
	WB-MW-05C	8.58e+01	Cretaceous
	WB-MW-06C	3.02e+00	Cretaceous
	WB-MW-07C	6.62e+01	Cretaceous
	WB-MW-08C	2.02e+01	Cretaceous
	WB-MW-09C	1.62e+02	Cretaceous
	WB-MW-10C	1.19e+02	Cretaceous
	WB-MW-11C	4.38e+02	Cretaceous
	WB-MW-12C	2.25e+01	Cretaceous
	WB-MW-15B	5.80e-01	Cretaceous
	WB-MW-15C	7.20e-01	Cretaceous
	WB-MW-16B	6.46e+00	Cretaceous
	WB-MW-17C	1.40e-01	Cretaceous
	WB-MW-18B	2.45e+00	Cretaceous
	WB-MW-18C	3.74e+01	Cretaceous
	WB-MW-19C	1.73e+00	Cretaceous
	WES-M-06	9.04e-01	Qt2 Unit C
	WES-M-11	1.01e+01	Qt2 Unit C
	WES-M-14	2.00e+01	Qt2 Unit C
	WES-M-15	3.77e-01	Qt2 Unit C
	WES-M-18	2.78e+00	Qt2 Unit C
	WES-M-19	3.27e+01	Qt2 Unit C
	WES-M-22	1.33e+01	Qt2 Unit C
	WES-M-23	3.25e+01	Qt2 Unit C
	WES-M-24	4.36e+00	Qt2 Unit C
	WES-M-25	5.13e-01	Qt2 Unit C
	WES-M-26	1.93e-01	Qt2 Unit C
	WES-M-27	2.19e+00	Qt2 Unit C
	WES-M-29	7.19e-01	Qt2 Unit C
	WES-M-30	1.89e-01	Qt2 Unit C
	WES-M-35	2.36e+00	Qt2 Unit C
	WES-M-36	5.04e+00	Qt2 Unit C
	WES-M-07	1.67e-02	Qt2 Unit B
	WES-M-12	9.92e-03	Qt2 Unit B
	WES-M-16	1.74e-01	Qt2 Unit B
	WES-M-20	9.07e-03	Qt2 Unit B
	WES-M-28	4.95e-03	Qt2 Unit B
	WES-M-31	8.37e-03	Qt2 Unit B
	WES-M-37	4.54e-03	Qt2 Unit B
Production wells at Phillips Army Airfield (PAAF)	PAAF 1 (B1040)	2.30e+02	Qt3
	PAAF 2 (B1041)	2.30e+02	Qt3
PAAF Landfill	PW-09	8.30e-01	Qt2 Unit C

Hydrographs

Most of the groundwater data on APG-AA prior to 1995 are from ground-water monitor wells screened in the water table aquifer. Prior to 1995, most of the wells screened in the Cretaceous were installed by water well drillers. Wells HA881640 and HA881641, which are about 20 ft apart, are the only monitor wells known to be screened near the contact between the Cretaceous sediments and metamorphic bedrock on APG-AA (Figure 55).

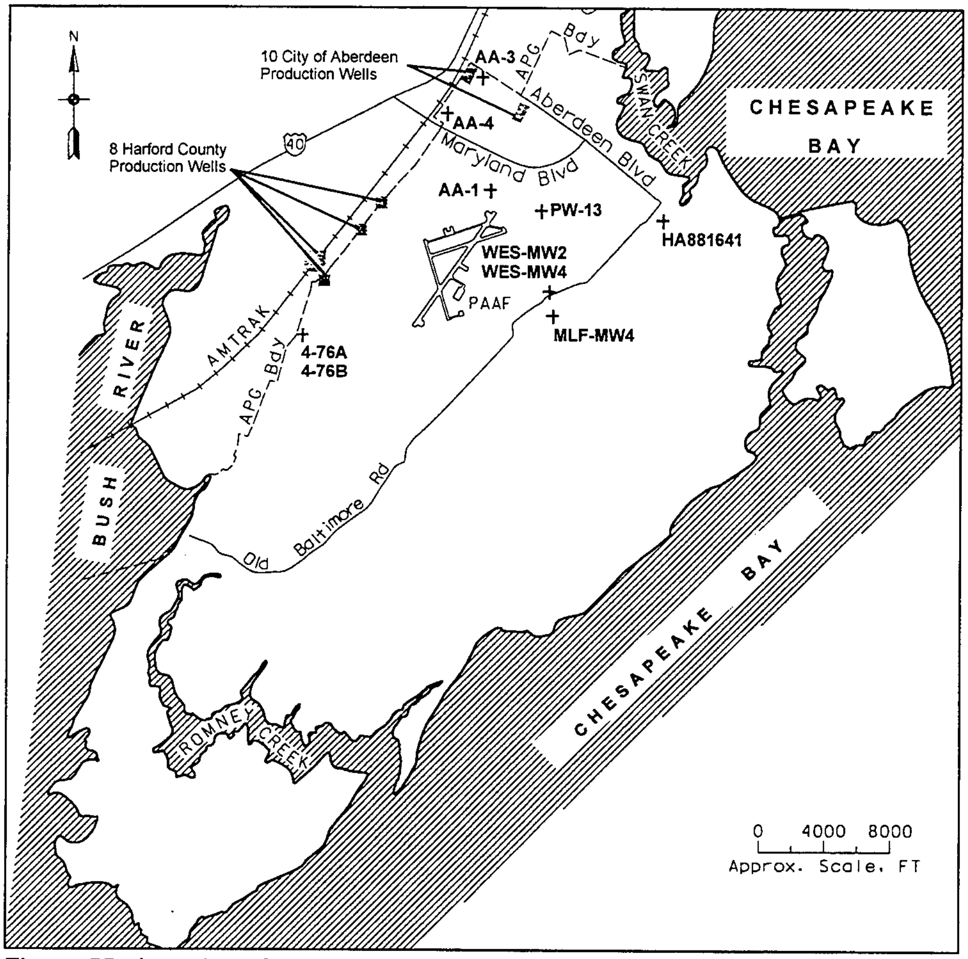


Figure 55. Location of monitor wells with hydrographs in Figures 56 and 57

The hydrographs in Figure 56 are for selected wells scattered across APG-AA. Monitor wells AA-1, AA-3, AA-4, PW-13, WES-MW2, MLF-MW4, and 4-76B are water table wells. All the water table wells are screened in the Qt3 terrace, except for PW-13, MLF-MW4, and WES-MW2 which are screened in Unit C of the Qt2 terrace. Well WES-MW4 is screened in Unit B of the Qt2 terrace. Wells 4-76A and HA881641 are screened in the Cretaceous.

Wells AA-3 and -4 are located approximately 500 ft east and 1,500 ft south, respectively, of the City of Aberdeen production wells CAP-1 through -6. The CAP wells and the AA wells are screened in the Qt3 terrace.

Wells 4-76A and -B is a cluster well site located approximately 2,500 ft

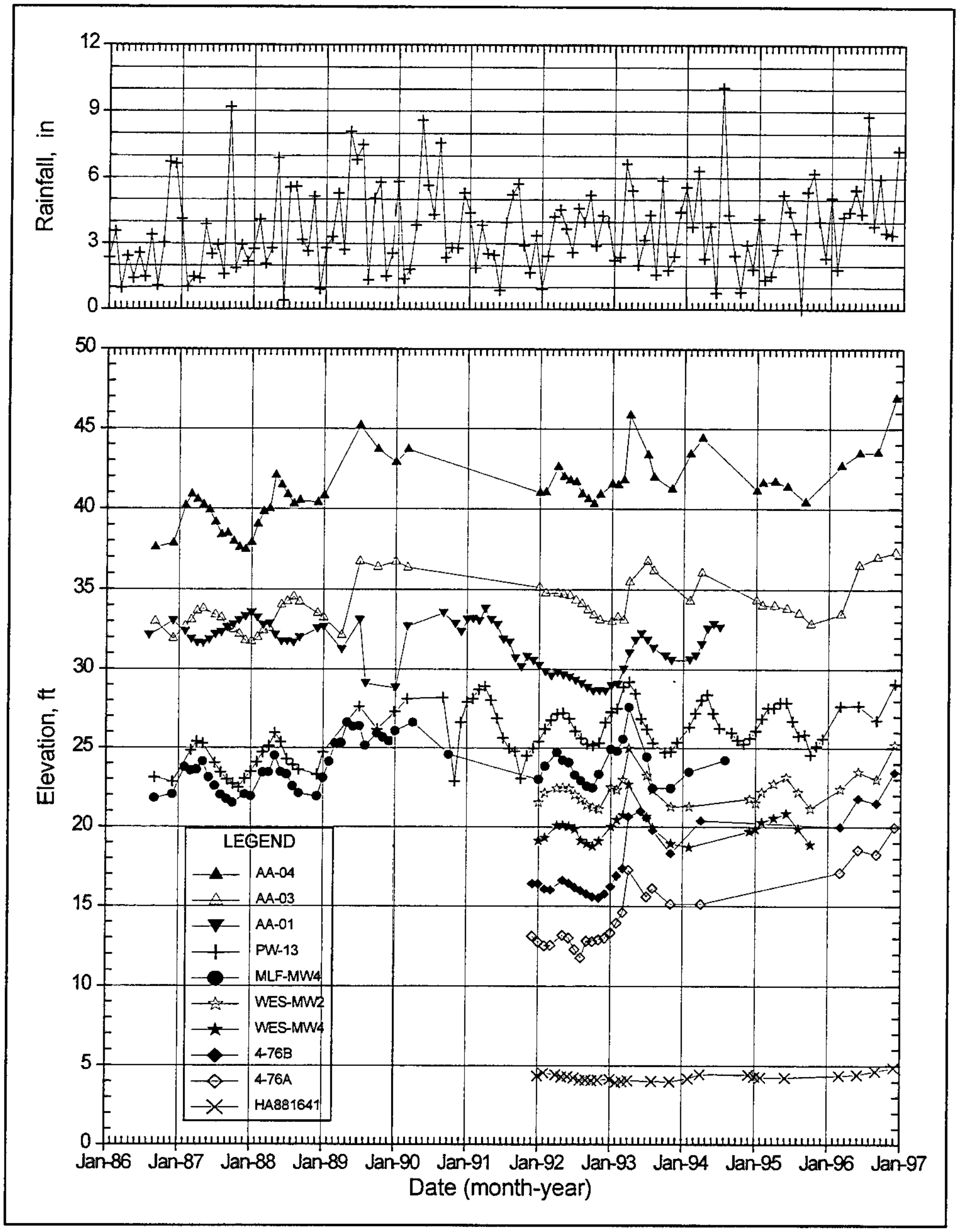


Figure 56. Hydrographs of selected monitor wells on APG-AA. A graph of monthly rainfall is shown at top of hydrographs.

south-southwest of the Harford County production well HCP-6. Well 4-76B is screened in the Qt3 and 4-76A is screened in a Cretaceous sand. The rise and fall of the water levels in 4-76A and -B mimic each other with 4-76B being 2 to 4 ft higher than 4-76A.

Wells WES-M2 and -M4 are a cluster well site at MLF. Well WES-M2 is screened at the top. Well WES-M4 is screened in the Qt2 Unit B. The water levels in well WES-M2 are always 2 to 3 ft higher than in WES-M4.

Water level data from the cluster wells installed during the Western Boundary Area investigation show how variable the interconnections are

between the water table aquifer and the permeable zones within the Cretaceous. Figure 57 shows hydrographs for five sets of the WBA cluster wells. The "A"

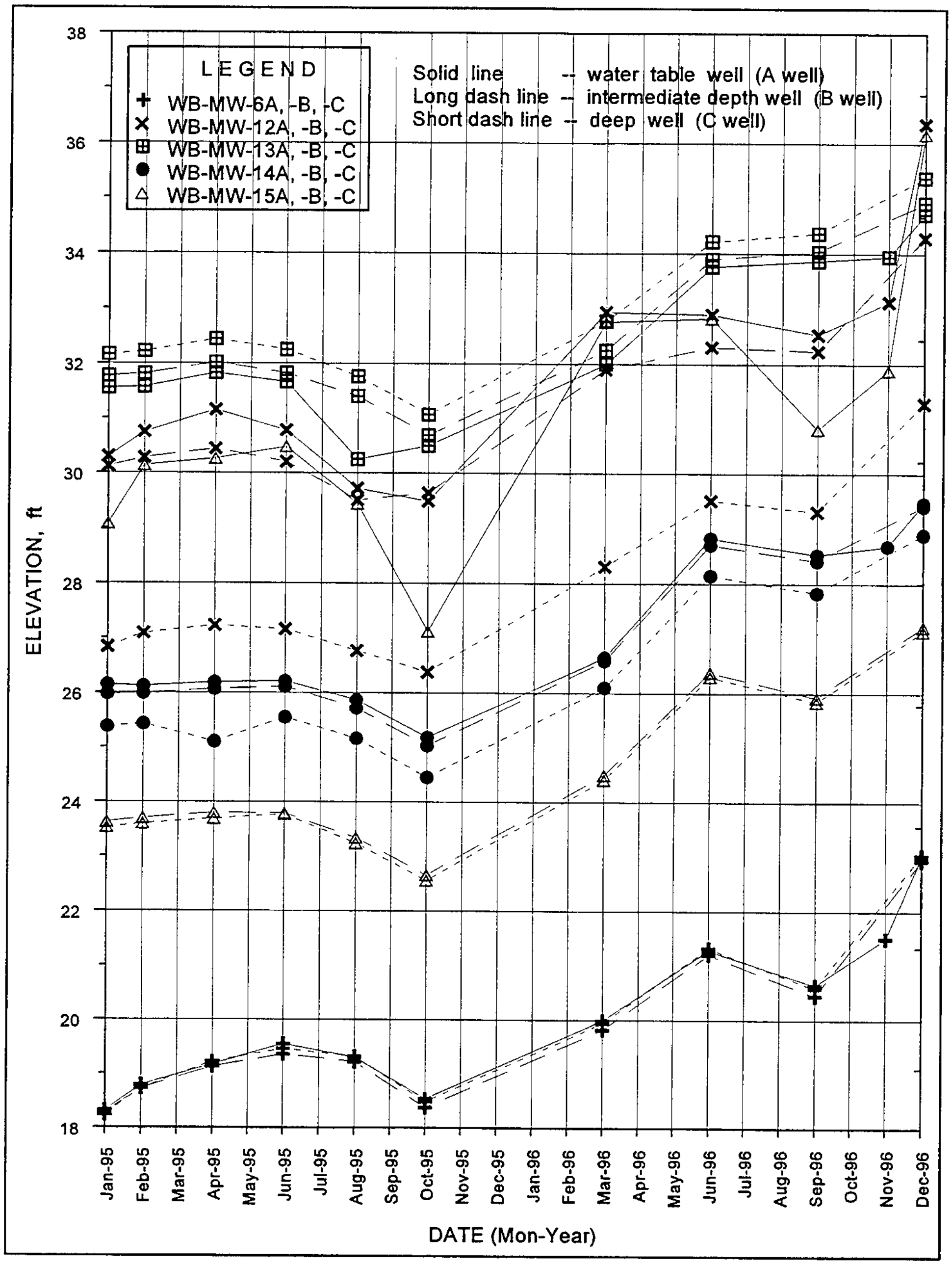


Figure 57. Hydrographs of selected Western Boundary cluster wells

wells in each cluster are water table wells. The "B" wells are screened near the bottom of the Qt3 terrace. The "C" wells are screened in the first permeable zone encountered in the Cretaceous. A comparison of the water level elevation data within each of the five sets of cluster wells shows water levels in :

a. WB-MW-6A, -B and -C are within a few tenths of a foot of being the same. Cluster 6 is a few hundred feet east of HCP-5 and -6, which are screened in the Qt3 and the Cretaceous units.

b. WB-MW-12A is generally 0.3 to 1 ft higher than in -12B, and about 3 ft

higher than in -12C. Cluster 12 is a few hundred feet east of HCP-9, which is screened in the Cretaceous.

c. WB-MW-13A is usually 0.3 to 0.4 ft lower than in -13B, and 0.5 to 1.0 ft lower than in -13C.

d. WB-MW-14A is usually 0.2 to 0.4 ft higher than in -14B, and about 1 ft higher than in -14C.

e. WB-MW-15A is 4 to 9 ft higher than in -15B and -15C. WB-MW-15B is usually 0.2 to 0.3 ft higher than -15C. Cluster 14 is about 2,000 ft north-northeast of cluster 15.

Available groundwater elevation data

Water level data for APG-AA have been collected at various sites, such as PAAFLF and MLF, since 1986. The data were collected at different times at each site. Synoptic water level data have been collected at APG-AA on a multi-site basis from January 1992 to the present. The data collection has varied from monthly to quarterly rounds and the number of wells included in each round has varied. The water level data that have been collected are in the Installation Restoration Management Information System (IRDMS) database which is at the U.S. Army Environmental Center (AEC), APG, and the APG Graphical Information System (GIS) database. Water level data for 10 rounds of synoptic water level readings collected in 1995 and 1996 are in Appendix B. The screen settings of the wells used in this effort are in Appendix C. The monitor wells used for the synoptic groundwater measurements have all been surveyed with reference to an off-post benchmark related to the North American Vertical Datum of 1988 (NAVD88) and the North American Horizontal Datum of 1983 (NAD83). Survey data for these wells are in Appendix D.

Surface water elevation data

Surface water elevations and streambed elevations were collected for selected locations in August of 1993. This survey work was conducted using benchmarks set by the APG department of Public Works with APG-AA horizontal and vertical control. In the course of surveying the monitor wells in the synoptic groundwater measurements, the surveyor noted that the listed elevations for control points located on APG-AA were generally greater than the projected NAVD88 elevation by an average factor of 0.81 ft. The surveyor noted that some APG-AA control points differed by greater or lesser amounts. He attributed this to the manner in which some of the original APG-AA control was laid out. These APG-AA control discrepancies were addressed in the well survey by referencing an off-post vertical datum. To compare the streambed and surface water elevations with the groundwater elevations, all of the streambed elevations and surface water elevations must be adjusted by subtracting 0.81 ft. The actual surface water and streambed survey results, as reported by the surveyor, are presented in Appendix E. Figure 58 shows the location of the survey points on APG-AA.

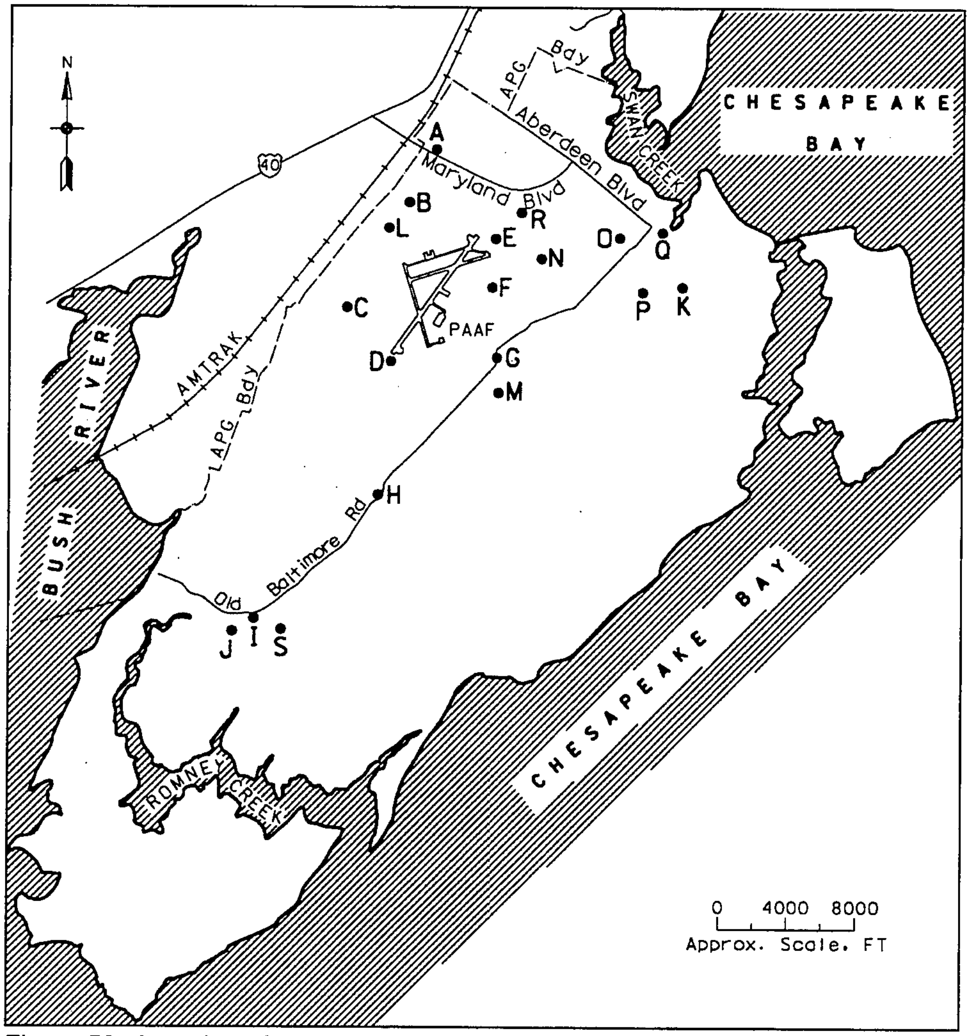


Figure 58. Location of survey points for surface water and streambed elevations on APG-AA

Surface Soils

There are two sources of soil data available for the Coastal Plain of Harford County. A soil map covering all of the county including APG-AA was published in 1927. This map indicated the distribution of soil series with some subdivision of series by textural differences. The current County Soil Survey published in 1975 covers all of the County except for APG-AA. Soil series in this report are subdivided further by slope, degree of erosion, and other standard soil parameters. (USDA 1927, USDA 1975).

The distribution of soil resulting from the 1927 survey is presented in Figure 59. The general diagnostic characteristics of the soil series identified in the 1927 survey are consistent with those presented in the 1975 report (Jones 1993). Each of the principal soil series present (Sassafras loams, Keyport silt loam, and Elkton silt loam) are described as being derived from multiple textured sediments of marine origin (USDA 1975). Presumably, much of the soil in the study area is actually derived from Pleistocene nonmarine deposits which cover

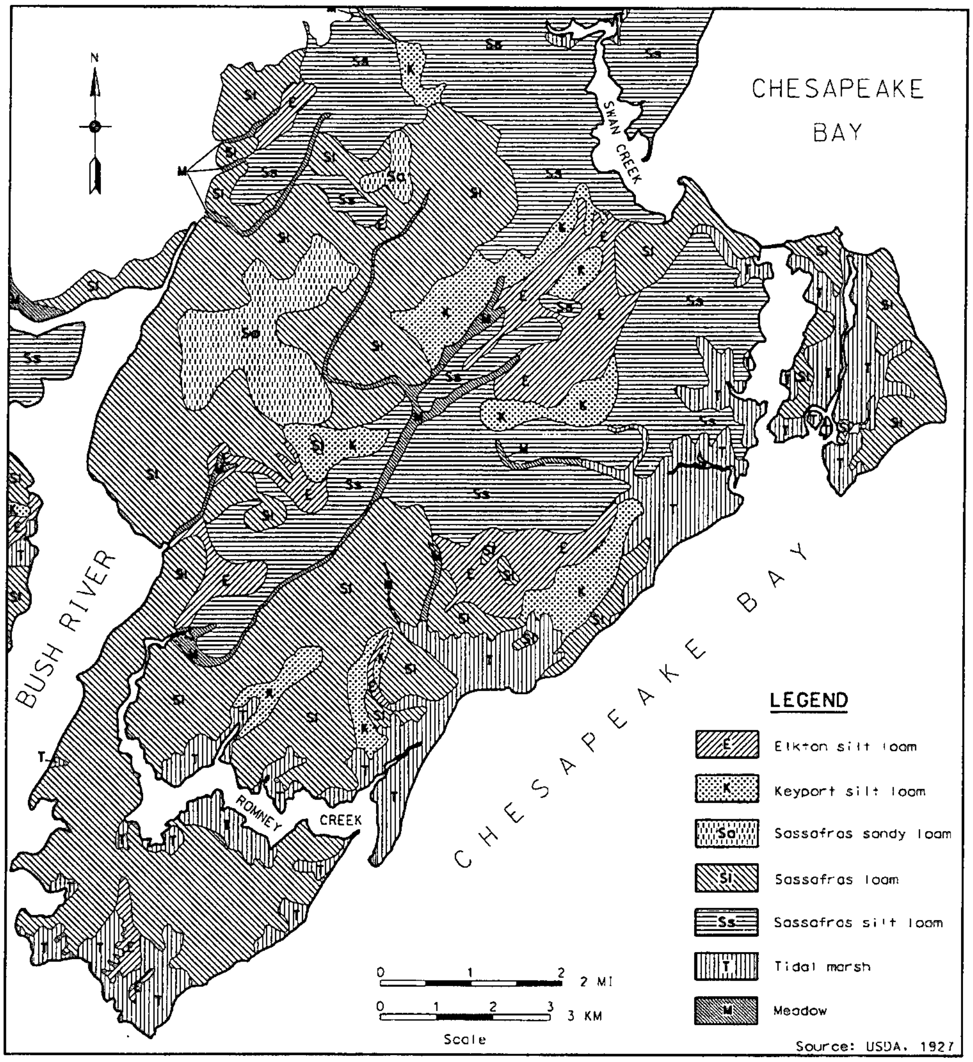


Figure 59. 1927 USDA soil map of APG-AA

much of the surface of the study area. Drainage data for the three soil series identified in the 1927 survey are presented in Table 6.

Groundwater Recharge

Recharge of the groundwater beneath APG-AA is primarily from the infiltration of precipitation (Table 1) through the vadose zone. Precipitation that does not enter the groundwater system may reenter the atmosphere through evaporation and transpiration or enter the Chesapeake Bay and its tributaries by means of surface runoff. Recharge may also be contributed, to a much lesser extent, by the interconnection of the Piedmont water table aquifer with the up-dip limits of the Coastal Plain sediments at the Fall Line.

Precipitation

Recharge to the water table aquifer in the western portion of APG-AA is

Table 6
Soil Drainage Data

Soil Series*	Depth Below Surface (inches)+	Estimated Permeability (Water) (inches/hour)+	Estimated Soil Reaction (pH)+
Sassafrass Loams	0 to 12	0.6 to 6.0	4.0 to 5.5
	12 to 40	0.6 to 2.0	4.0 to 5.5
	40 to 60	0.6 to 6.0	4.0 to 5.5
Keyport Silt Loam	0 to 7	0.6 to 2.0	4.0 to 5.0
	7 to 42	< 0.2	4.0 to 5.0
	42 to 55	< 0.6	4.0 to 5.0
Elkton Silt Loams	0 to 7	0.2 to 2.0	4.0 to 5.5
	7 to 34	< 0.2	4.0 to 5.5
	34 to 60	0.2 to 6.0	4.0 to 5.0

* Source: USDA (1927) + Source: USDA (1975)

significantly greater than that of the eastern portion. The ground surface in the western portion of APG-AA is composed of very permeable coarse grained Qt3 terrace sediments, whereas the soils in the eastern portion of APG-AA are typically silts and/or clays of the Qt2 Unit C . The actual amount of recharge to the water table aquifer is dependent on a number of factors, including surface drainage and the specific yield of the aquifer material and the vadose zone. Figure 60 shows the rise in the water table from September 1996 to December 1996. Heavy rains during the latter part of November and first weeks of December resulted in up to a 4.5-ft rise in the water table in some areas of APG-AA. Note that the operation of the City of Aberdeen production wells 7 through 10 have lowered the water table in that area of APG-AA while areas a few thousand feet away has risen 2 to 3 ft. The water table in the flat, low lying, swampy area to the east of PAAF has risen 3 to 4 ft. The area east of PAAF has some areas of standing water throughout much of the year. The 4-ft rise in the water table directly at the southeast end of PAAF is probably associated with an impoundment on Romney Creek; however, the 3- to 4-ft rise in the area southwest of PAAF is in an area of well-drained surface soils of the Qt3 terrace.

Influent drainage

The role of streams as a means of groundwater recharge has not been investigated at APG-AA. A preliminary review of water table topography in conjunction with stream bed topography indicates that the stream flow in the upper reach of Romney Creek northeast of Perryman varies throughout the year from a source of recharge to the water table to discharging from the water table. This condition is the result of the operation of the City of Aberdeen and Perryman well fields and varying precipitation.

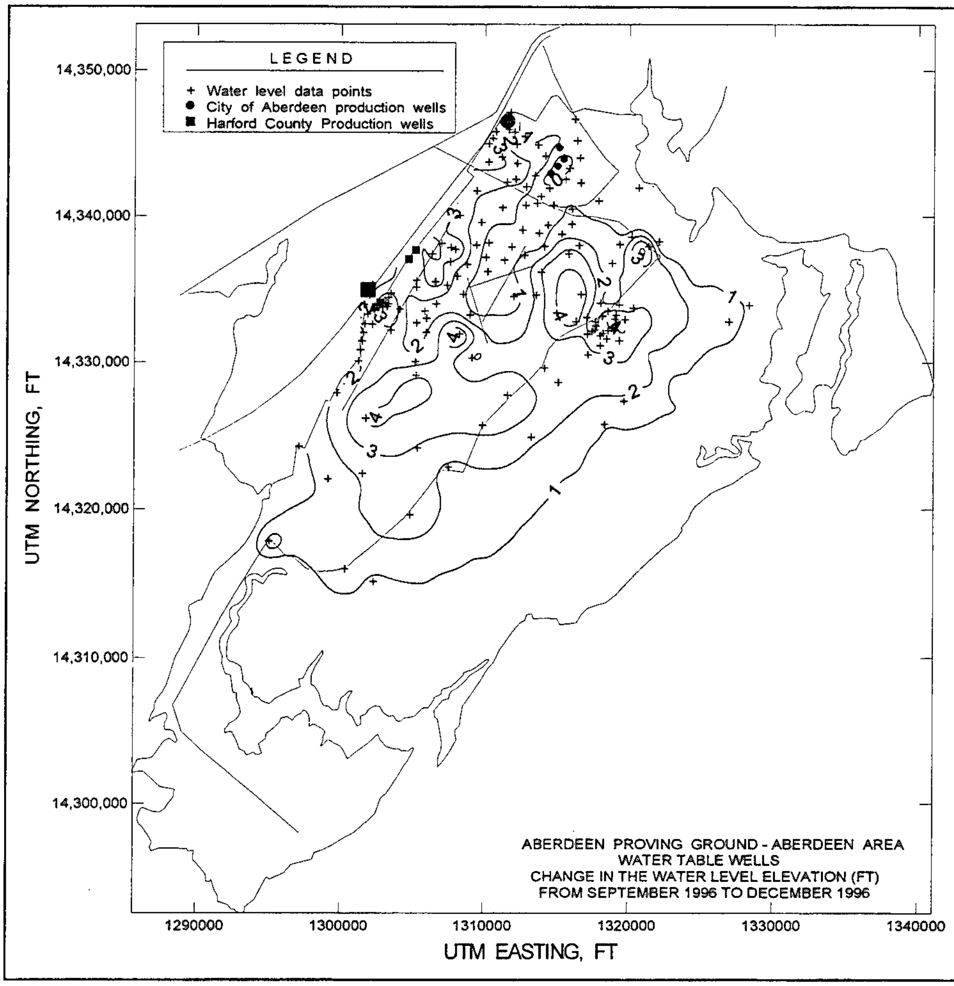


Figure 60. Change in water table elevation from September to December 1996

Potential artificial recharge

There are many sites of potential recharge located at APG-AA. Numerous surface water impoundments for wildlife enhancement and storm water management have been constructed and are of sufficient size to possibly influence local groundwater flow. There is no central source of information concerning any of these impoundments. A potential additional source of groundwater recharge is exfiltration of water from the water supply distribution system and possibly from sewage system force mains.

Groundwater discharge

Natural groundwater discharge and man-made groundwater extraction systems are the two primary methods of groundwater discharge at APG-AA. Natural groundwater discharge occurs primarily from the maintenance of base flow in effluent streams and evapotranspiration. The stream segments affected by groundwater discharge vary seasonally. This relationship may be seen, to a limited extent, by analysis of the water table elevation maps found in the Groundwater Contour Mapping section of this report. Estimated

evapotranspiration data are shown in Table 7.

TABLE 7

Estimated Pan Evaporation and Evapotranspiration for the Perryman Site

Parameter	Evaporation (inches per month)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PER[1]	0.62	0.84	2.17	4.50	5.27	6.00	6.20	5.58	3.90	3.10	1.80	0.93
Est. Evap.[2]	0.47	0.64	1.65	3.42	4.01	4.71	4.71	4.24	2.96	2.36	1.37	0.71

Annual total PER 40.91 in. Annual total Estimated Evapotranspiration

[1] Pan evaporation record data from pan station at Upper Marlboro, MD, from 1900

[2] Estimated evapotranspiration is calculated from pan evaporation with a pan coefficient

Source : Rafalko and Keating 1990

The unimpounded, perennial streams on APG-AA appear to be gaining streams in most cases. Groundwater contour mapping of the water table aquifer tends to support this conclusion. Long-term streamflow monitoring has not been conducted on APG-AA. Measurements have been made at two locations on Mosquito Creek in support of an environmental study conducted by the Los Alamos National Laboratory for ATC, formerly called CSTA (Ebinger 1993). These locations, in addition to two stream gauge stations operated by the USGS on Cranberry Run, are shown on Figure 61. The recorded data for the USGS gauge stations on Cranberry Run are presented in Appendix F.

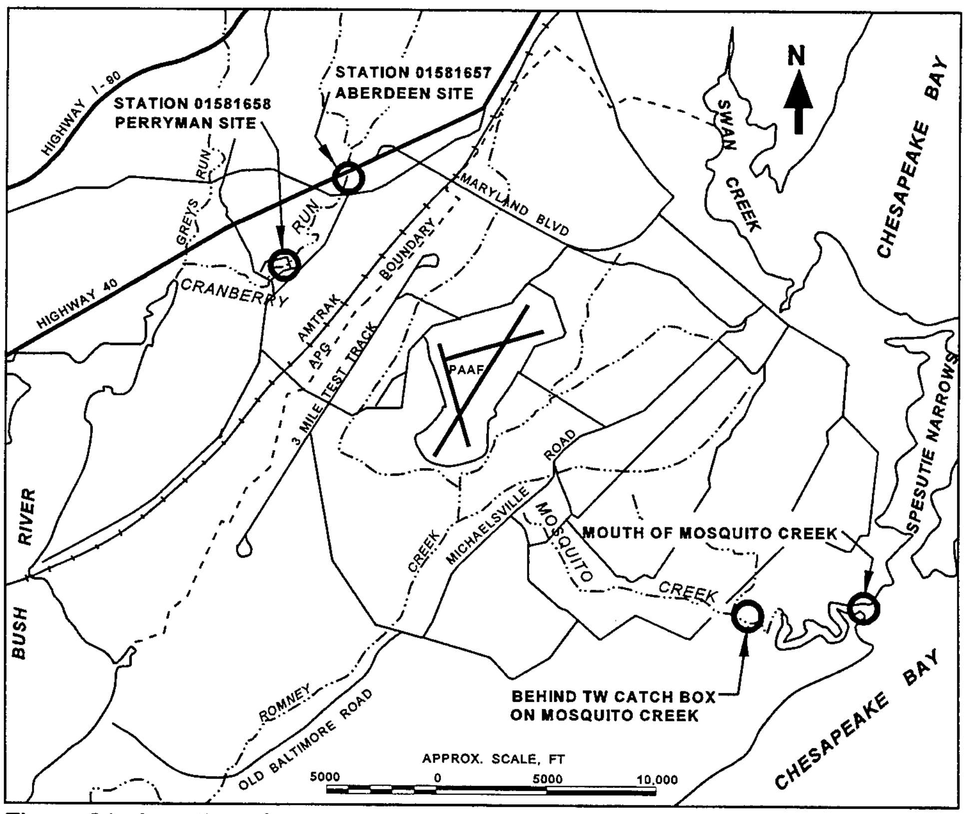


Figure 61. Location of stream gauge stations

Numerous centers of large-scale groundwater withdrawal (Figure 62) are present in the study area. These pumping centers include industrial and municipal users withdrawing water from multiple aquifers. Data derived from state permits and well records concerning these groundwater users are presented in Table 8. The historical production for the Harford County (Perryman) and City of Aberdeen well fields are presented in Figure 63.

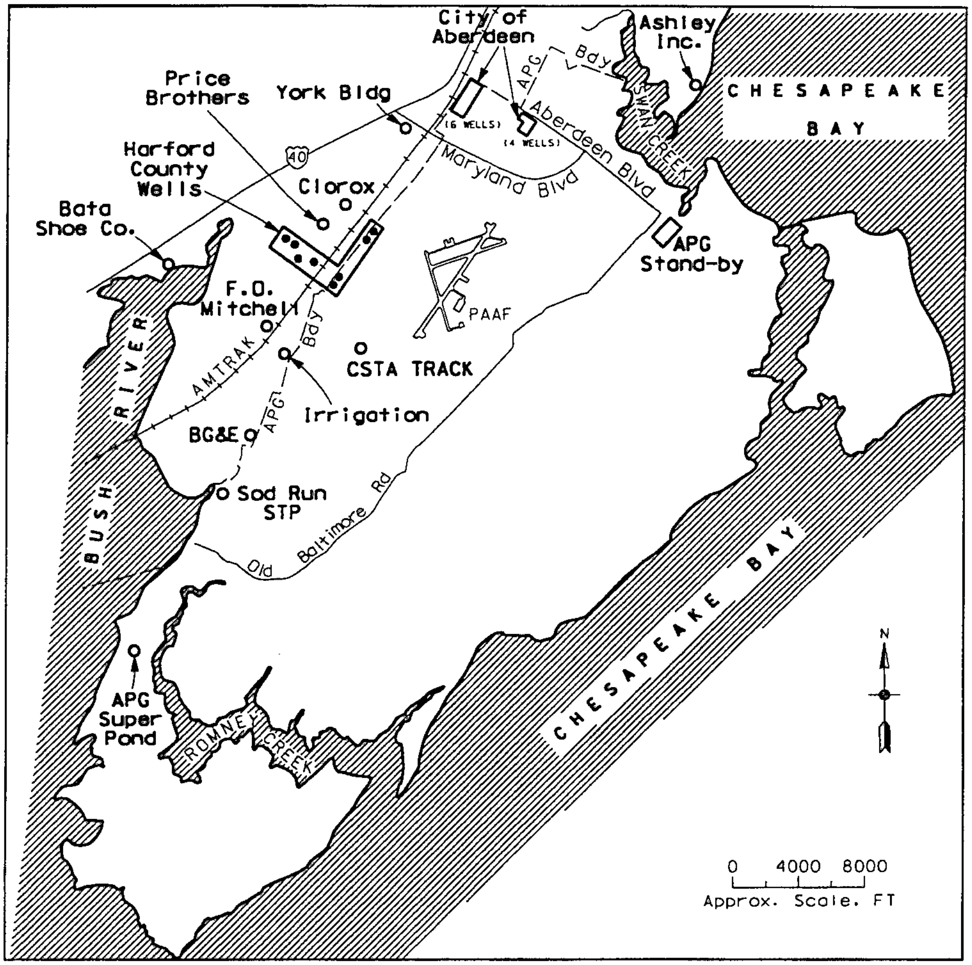


Figure 62. Locations of currently permitted large groundwater withdrawals

Groundwater Contour Mapping

Groundwater elevation contour maps for four rounds of water level data (March, June, September, and December of 1996) on APG-AA are shown in Figures 64 through 67. The water table contour maps include water level data from those wells and piezometers screened at the water table. The Cretaceous water table maps include water level data only from those wells and piezometers screened in and near the top of the Cretaceous. The complete sets of water level data for each of the four rounds of water level data are presented in Appendix B.

Table 8
Permitted Groundwater Withdrawal Points

Name	Estimated Pumping, gal/day	Estimated Pump Capacity, gpm	Aquifer	Screen Setting[a] Elevation[b],ft
APG-CSTA Track	3000[c]	----	Qt3	-21 to -29
APG-Superpond	300000[c]	----	Qt2	No Screen
F.O. Mitchell	1000[c]	----	Qt3	-6 to -11
York Building	1500[c]	----	----	----
Ashley In.	8000[c]	----	----	-55 to -70
Prie Bros.	140000[c]	----	Cretaeous	-41 to -61
Irrigation	15000[c]	----	Cretaeous	-48 to -150
Sod Run STP	20000[c]	----	----	----
BG&E	3200[c]	----	Cretaeous	-64 to -179
Bata Shoe o.	75000[c]	----	----	----
lorox o.	197000[c]	----	Cretaceous	----
City of Aberdeen Production Wells (11)				
CAP-1	288000	228	Qt3	26 to 3
CAP-2	172800	299	Qt3	22 to 2
CAP-3	288000	260	Qt3	23 to 1
CAP-4	230400	180	Qt3	31 to 4
CAP-5	158400	165	Qt3	43 to 17
CAP-6	0	96	Qt3	41 to 25
CAP-7	158400	112	Qt3[d]	15 to 0
CAP-8	57600	257	Qt3[d]	17 to -13
CAP-9	115200	175	Qt3	21 to 6
CAP-10	158400	149	Qt3[d]	10 to -5
CAP-11	108000	75	Qt3	----
Harford County Production Wells (8)				
HCP-1	155520	110	Cretaceous	-54 to -63
HCP-2	264960	200	Cretaceous	-78 to -93
HCP-3	0	150	Cretaceous	-68 to -88
HCP-4	936000	700	Cretaceous	-56 to -103
HCP-5	712800	400	Cretaceous	-19 to -66
HCP-6	1173600	800	Cretaceous	-19 to -48
HCP-8	578880	350	Cretaceous	-68 to -91
HCP-9	466560	300	Cretaceous	-17 to -48
APG Stand-by Wells (3)				
APG-P2	0	477	Qt2 Unit B and A	-70 to -132
APG-P3	0	500	Qt2 Unit B and A	-107 to -130
APG-P5	0	430	Qt2 Unit B and A	-118 to -136

a Elevations are approximate
b Elevation of top of highest screen and base of lowest screen for multiple screened wells
c Estimated from permitt
d Bottom few feet of screen in fine Cretaceous sands
---- Data unavailable at this time

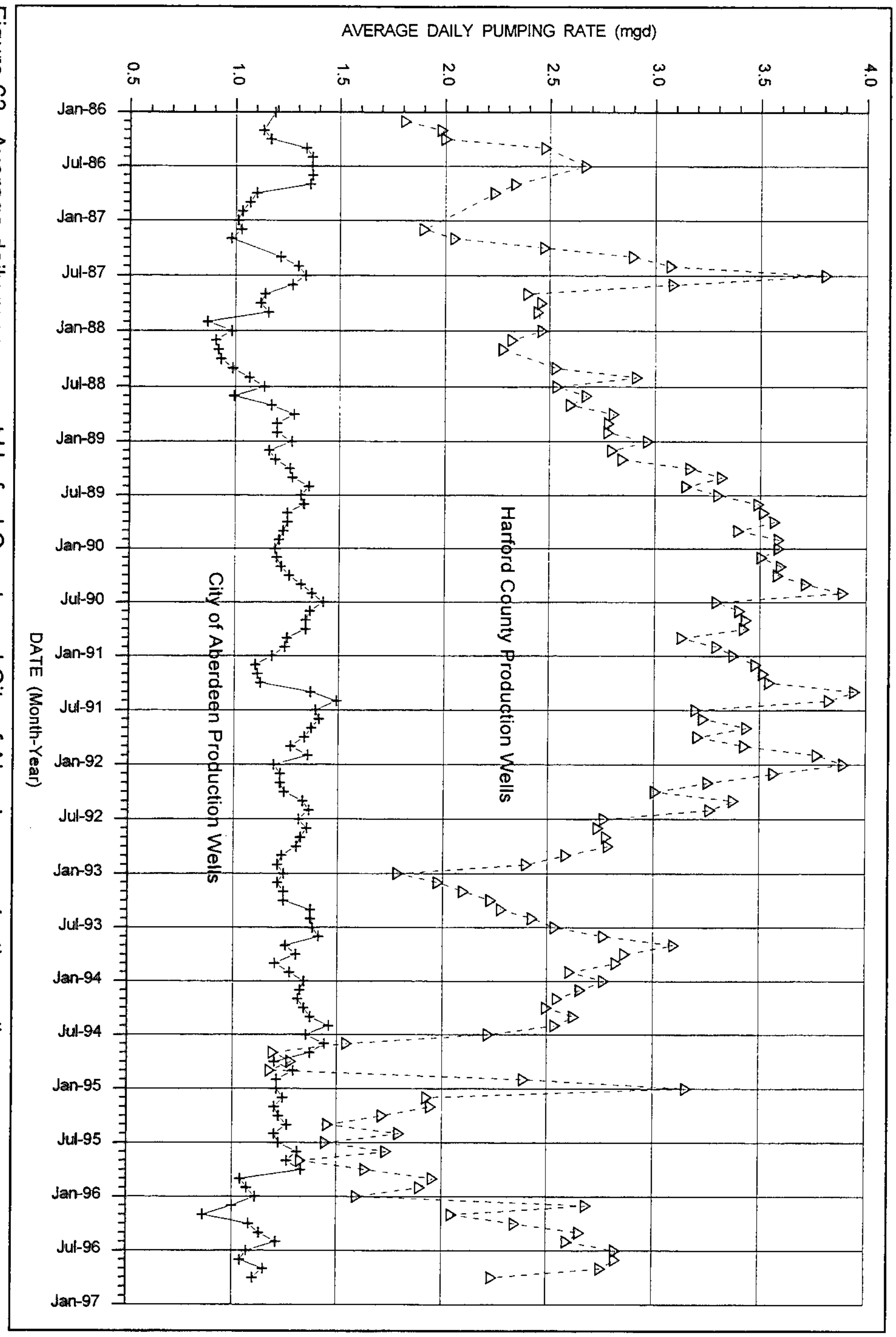


Figure 63. Average daily pumpage at Harford County and City of Aberdeen production wells

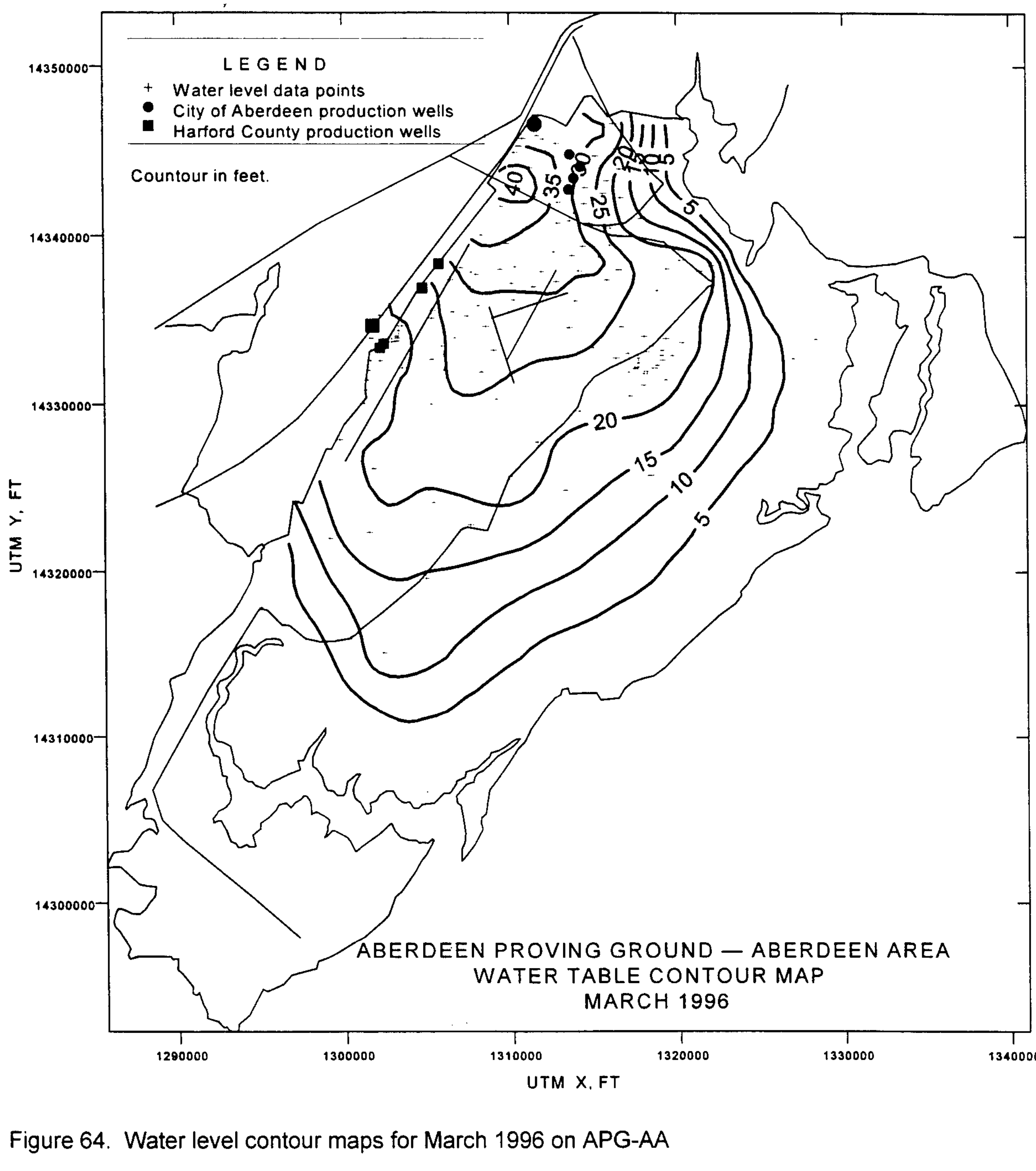
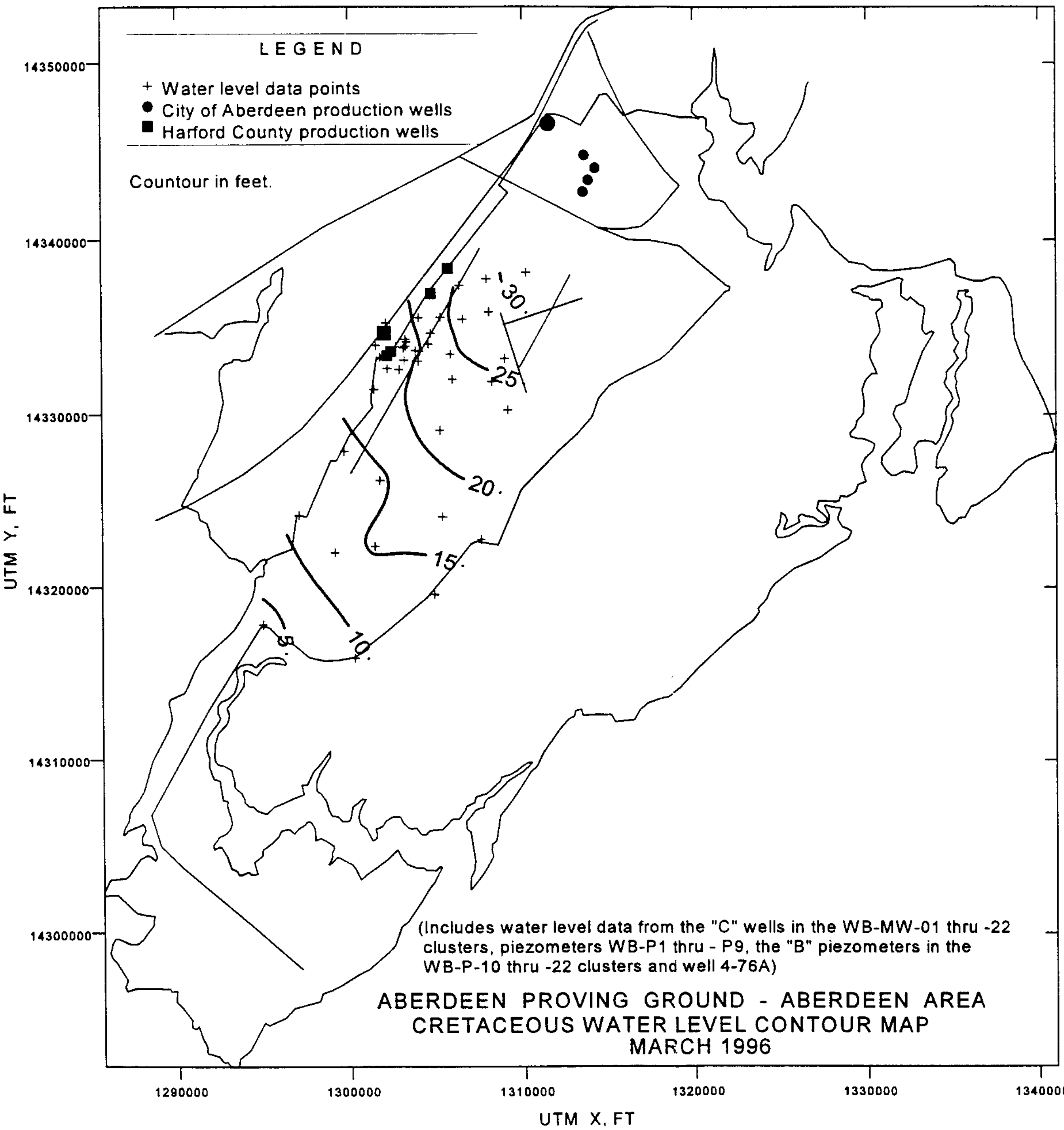


Figure 64. Water level contour maps for March 1996 on APG-AA


LEGEND
+ Water level data points
● City of Aberdeen production wells
■ Harford County production wells
Countour in feet.
14350000
14340000
14330000
14320000
14310000
14300000
UTM Y, FT
1290000
1300000
1310000
1320000
1330000
1340000
UTM X, FT
30.
25
20.
15.
10.
5.
(Includes water level data from the "C" wells in the WB-MW-01 thru -22 clusters, piezometers WB-P1 thru - P9, the "B" piezometers in the WB-P-10 thru -22 clusters and well 4-76A)
ABERDEEN PROVING GROUND - ABERDEEN AREA
CRETACEOUS WATER LEVEL CONTOUR MAP
MARCH 1996

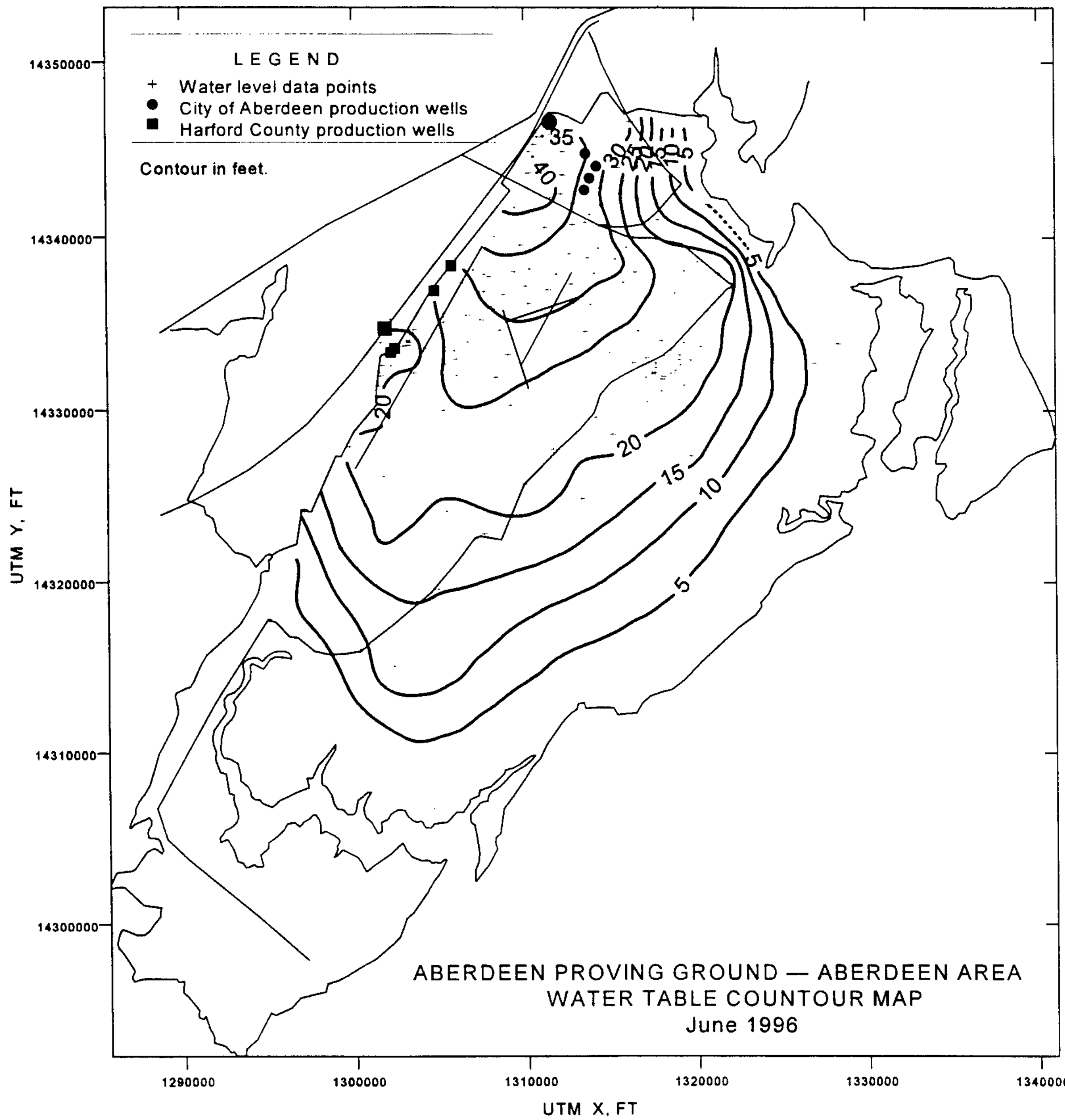
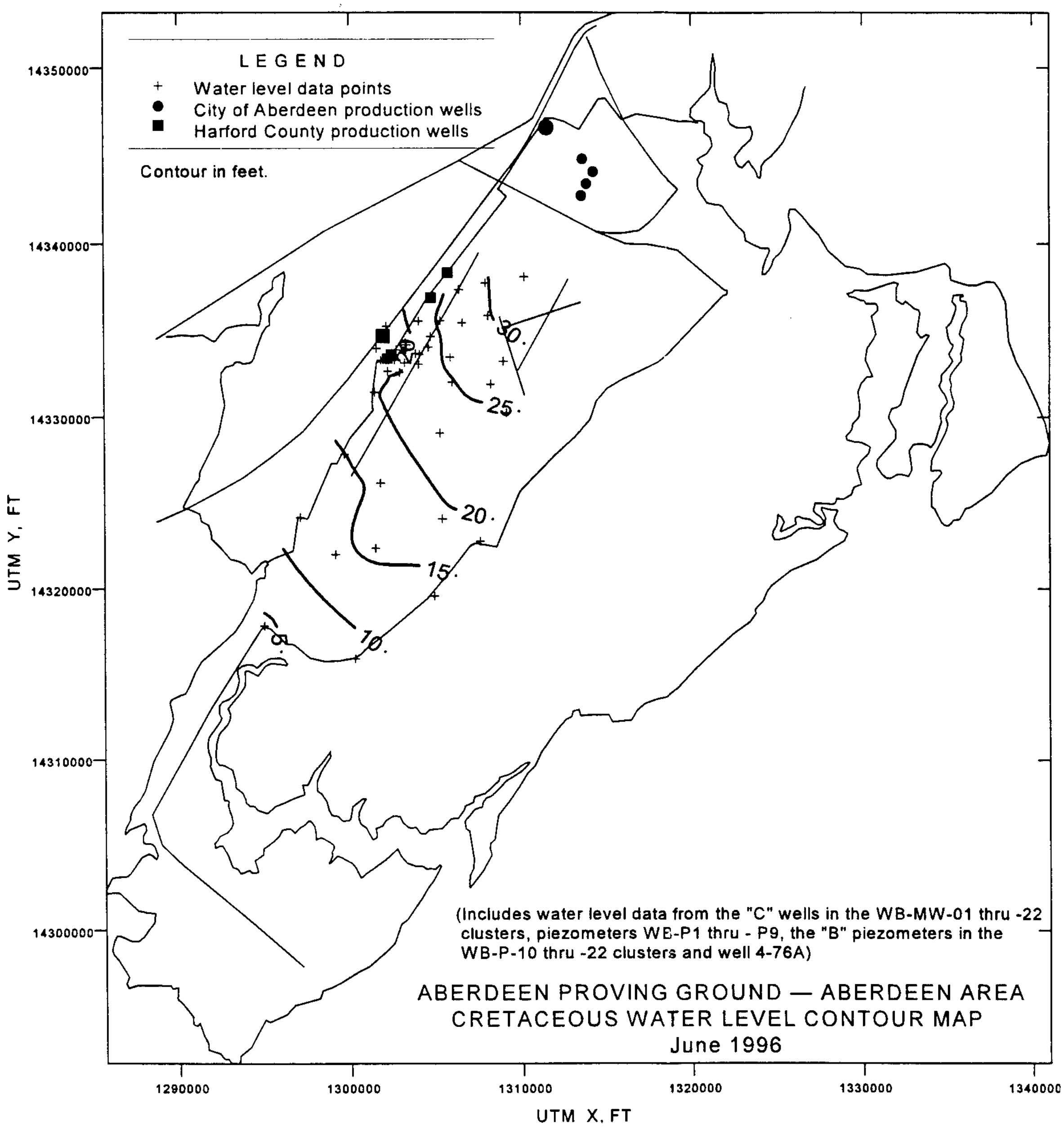


Figure 65. Water level contour maps for June 1996 on APG-AA



LEGEND
Water level data points
City of Aberdeen production wells
Harford County production wells
Contour in feet.
30.
25.
20.
15.
10.
5.
(Includes water level data from the "C" wells in the WB-MW-01 thru -22 clusters, piezometers WB-P1 thru - P9, the "B" piezometers in the WB-P-10 thru -22 clusters and well 4-76A)
ABERDEEN PROVING GROUND — ABERDEEN AREA
CRETACEOUS WATER LEVEL CONTOUR MAP
June 1996
14350000
14340000
14330000
14320000
14310000
14300000
UTM Y, FT
1290000
1300000
1310000
1320000
1330000
1340000
UTM X, FT

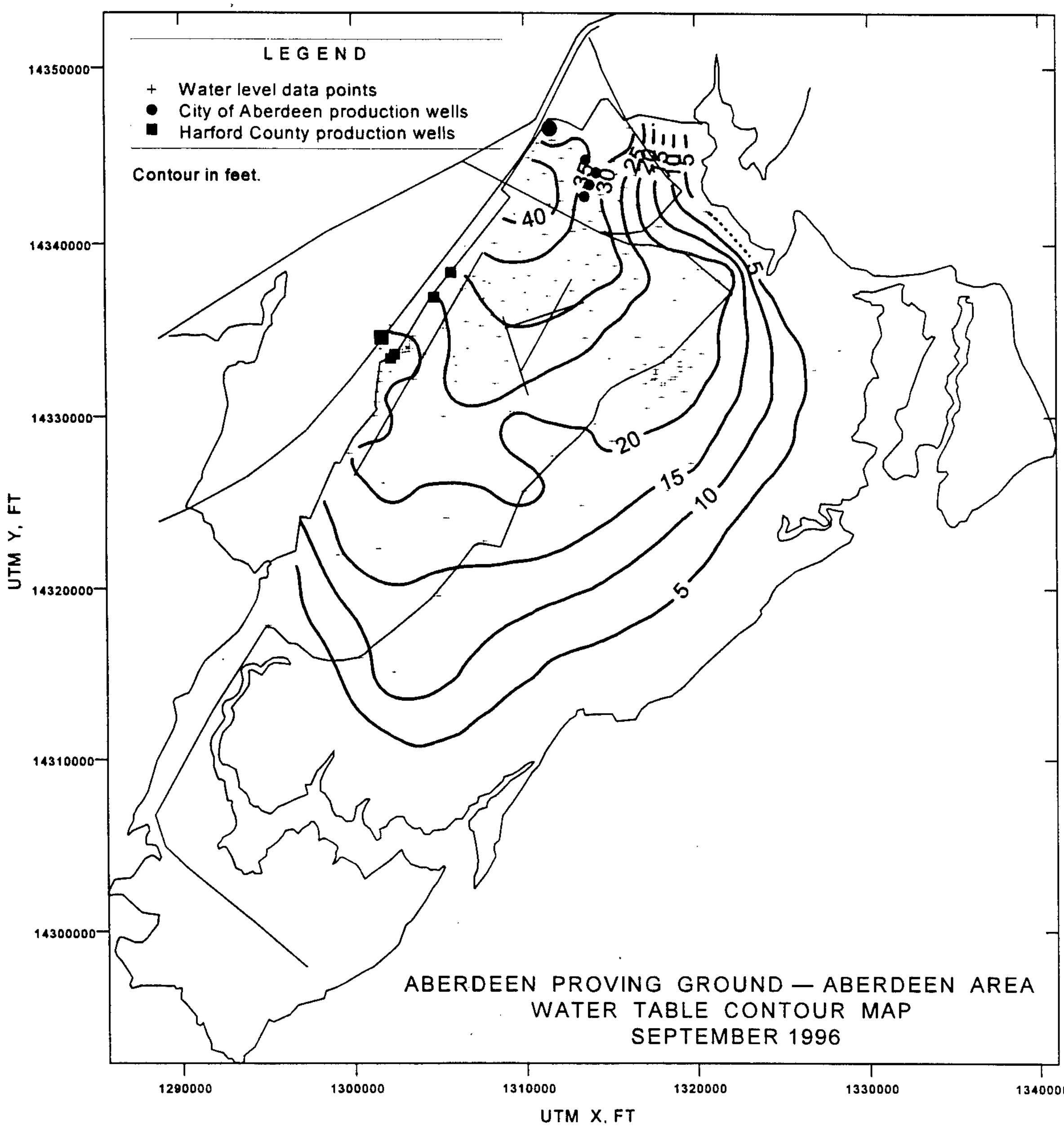
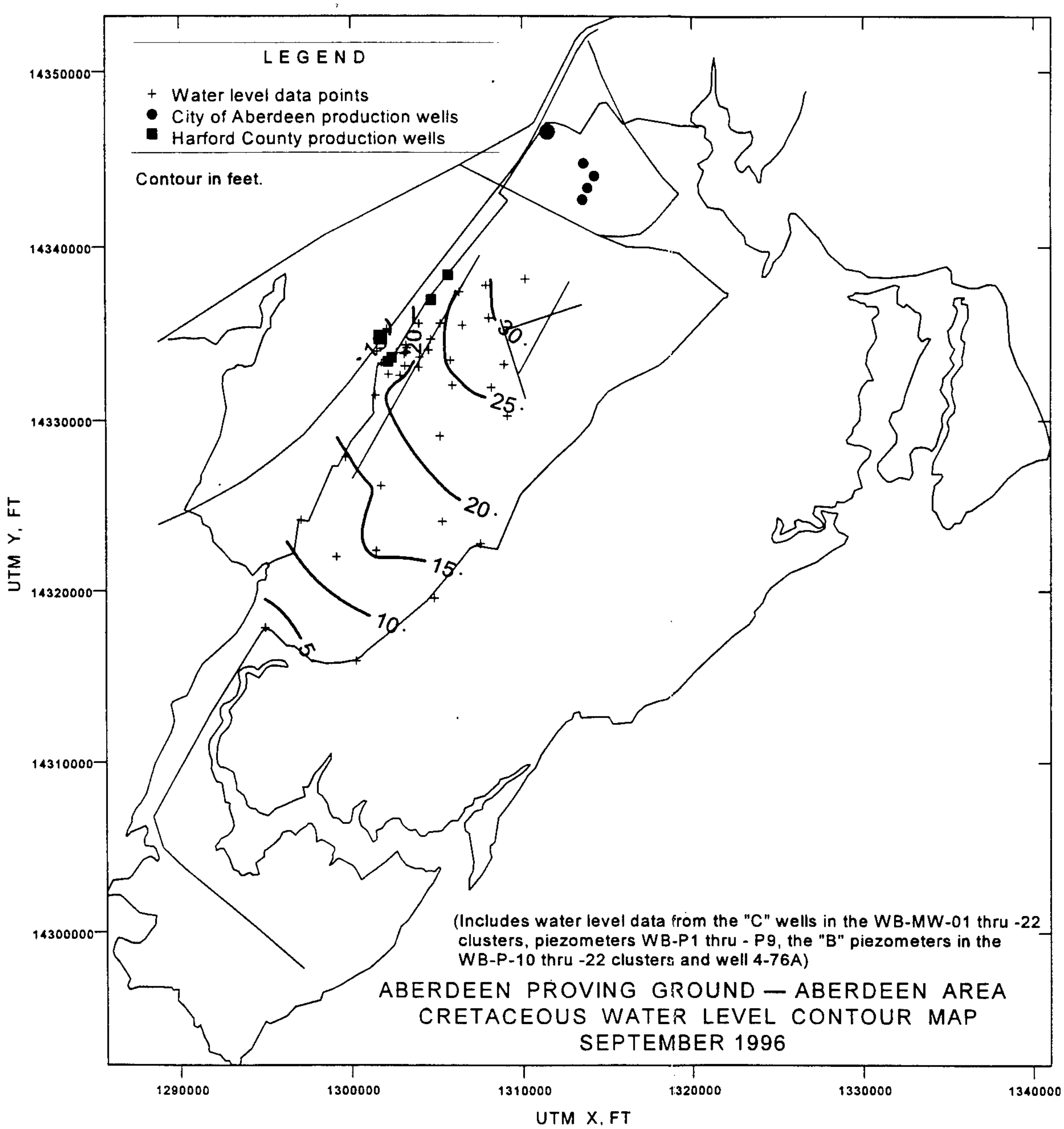


Figure 66. Water level contour maps for September 1996 on APG-AA


LEGEND
+ Water level data points
● City of Aberdeen production wells
■ Harford County production wells
Contour in feet.
(Includes water level data from the "C" wells in the WB-MW-01 thru -22 clusters, piezometers WB-P1 thru - P9, the "B" piezometers in the WB-P-10 thru -22 clusters and well 4-76A)
ABERDEEN PROVING GROUND — ABERDEEN AREA
CRETACEOUS WATER LEVEL CONTOUR MAP
SEPTEMBER 1996
UTM Y, FT
UTM X, FT
14350000
14340000
14330000
14320000
14310000
14300000
1290000
1300000
1310000
1320000
1330000
1340000
30.
25.
20.
15.
10.
5

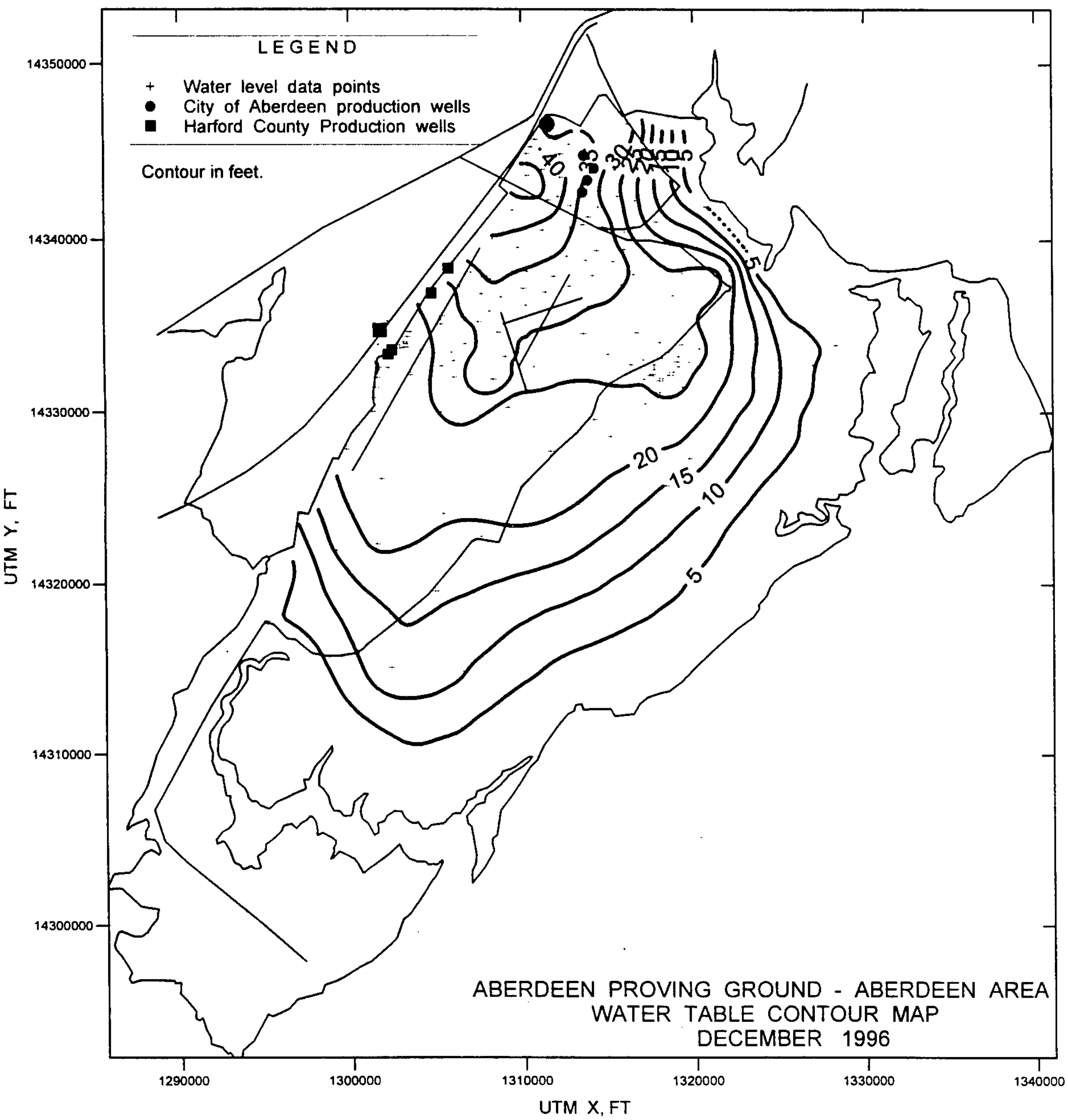
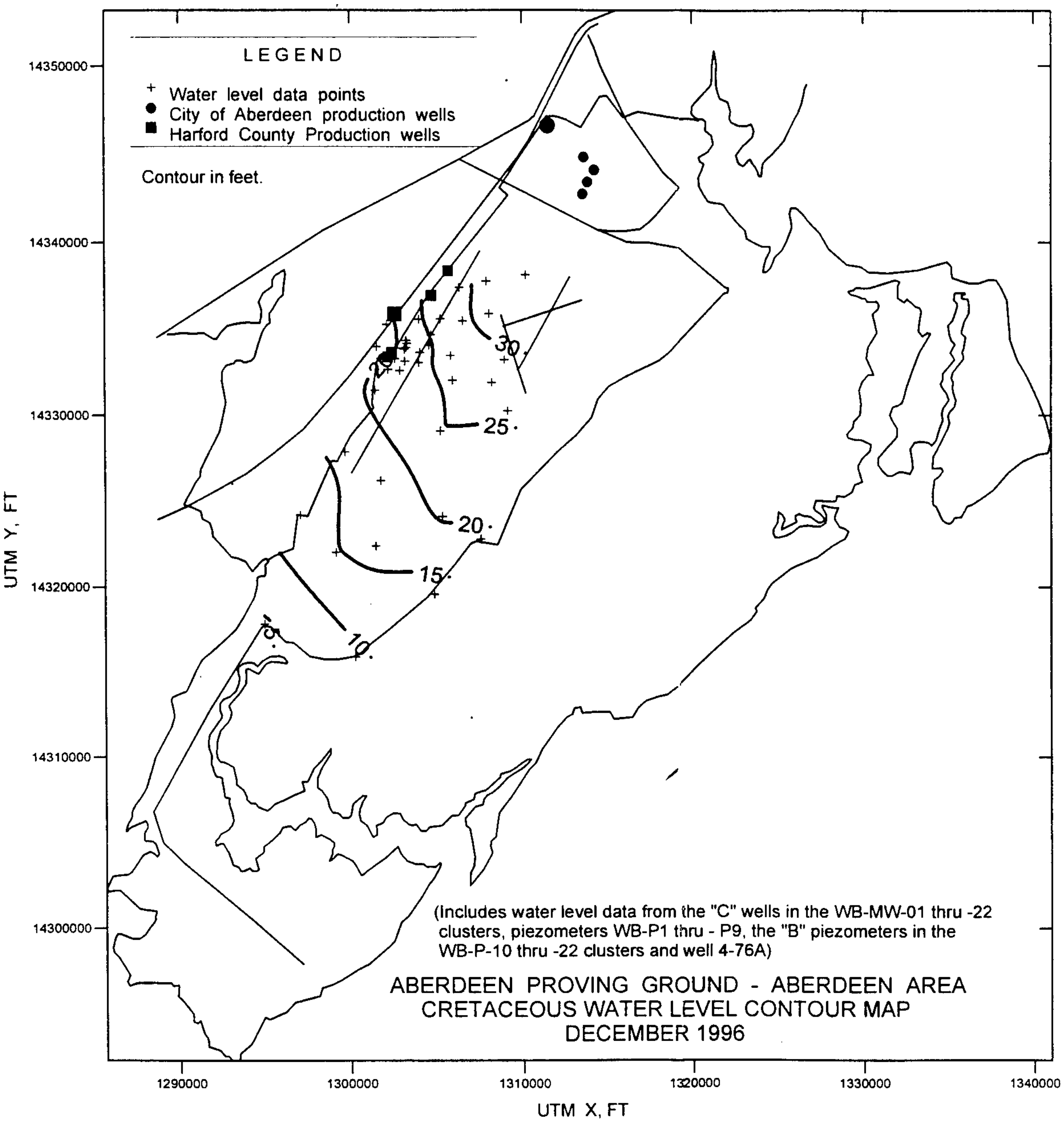


Figure 67. Water level contour maps for December 1996 on APG-AA


LEGEND
Water level data points
City of Aberdeen production wells
Harford County Production wells
Contour in feet.
30
25
20
15
10
5
(Includes water level data from the "C" wells in the WB-MW-01 thru -22 clusters, piezometers WB-P1 thru - P9, the "B" piezometers in the WB-P-10 thru -22 clusters and well 4-76A)
ABERDEEN PROVING GROUND - ABERDEEN AREA
CRETACEOUS WATER LEVEL CONTOUR MAP
DECEMBER 1996
14350000
14340000
14330000
14320000
14310000
14300000
UTM Y, FT
1290000
1300000
1310000
1320000
1330000
1340000
UTM X, FT

This Page Intentionaly
Left Blank

The drawdown of the water table aquifer by the 11 City of Aberdeen production wells and the eight Harford County production wells can be seen on all four water table maps. All of the City of Aberdeen wells are screened in the Qt3. Harford County wells 1, 2, 3, 4, and 8 are screened in the Cretaceous, wells 5 and 9 in the Qt3, and well 6 in both the Qt3 and Cretaceous sediments. The Qt3 directly overlies the Cretaceous sands in which Harford County wells 1, 2, 3, 4, and 8 are screened.

Cretaceous sediments outcrop along the bluff at Swan Creek. The top of Cretaceous maps show a Cretaceous high that dips to the south along the northern edge of APG-AA. The closer spacing of the water table contour lines in the area between the City of Aberdeen wells and Swan Creek show the combined effects of the thinning of the highly permeable Qt3 aquifer and the lower permeability of the finer grained Cretaceous sediments.

The flow patterns in the water table aquifer do not appear to change with the seasonal changes in precipitation. The heavy rains in the latter part of November and first weeks of December 1996 raised the water table from 1 to 4.5 ft across APG-AA. As shown in Figure 61, the recharge to the water table aquifer was not uniform across APG-AA, however the flow patterns in the water table map for December 1996 were similar to those for March, June, and September of 1996.

Water level data for the Cretaceous units are limited primarily to the monitor wells and piezometers installed in the top of the Cretaceous during the WBA RI study. These wells and piezometers were generally screened in the first permeable zone in the Cretaceous. The permeable Cretaceous sediments could not be correlated across the area. Hydrographs of the well clusters in the Western Boundary Area show the difference in the water level elevation in the Cretaceous and water table wells at different clusters vary from a few tenths of a foot to several feet with the water table wells usually being higher. The water level elevation in the Cretaceous well at cluster WB-MW-13 is consistently 0.50 to 0.75 ft higher than the shallow water table well. The four water level contour maps of the Cretaceous wells show that the groundwater flow patterns appear to be similar to those in the water table wells. The effects of the Harford County production wells can be seen on all Cretaceous contour maps.

3 Data Synthesis

The following section combines much of the data described in Chapter Two into a conceptual geologic model encompassing the entire APG-AA and adjacent off-post areas.

Limitations of Existing Data

The bulk of the data for APG-AA is related to specific areas in the northern half of the installation, primarily between the western boundary and Old Baltimore and Michaelsville Roads. There are two principal types of geologic data on APG-AA:

a. Well documented geotechnical data from environmental studies exist, with soil descriptions and surveyed x, y, and z data. The majority of the data are from 0 to 100 ft in depth. The WBA RI (USAEDB 1996a, b) provided the majority of the geologic data.

b. Water well drillers boring logs with no survey data exist. These data are generally scattered throughout the cantonment area where individual supply wells have been installed from 100 to 200 ft in depth. There is a concentration of deep borings to the bedrock along the northern two-thirds of the western boundary where Harford County and the City of Aberdeen have installed 19 public supply wells.

There are very limited geologic data in the form of boring data in the area south and east of the Old Baltimore and Michaelsville Roads.

The Baltimore Gas and Electric investigations (Figure 13) provided good geologic data for the area between the Bush River, the APG-AA boundary, and the Amtrak railroad. Water well driller logs were used in other off-post areas.

Conceptual Geological Model

Geologic model

Geologic cross sections (Figures 45 through 54) were developed for the Aberdeen Peninsula. These cross sections are tied to geologic cross sections

being prepared for the APG-EA. The cross sections primarily cover the northwestern half of APG-AA, from which the bulk of the geologic data were derived.

The first step in constructing the cross sections was the construction of a top of bedrock map (Figure 34). The locations of all the borings to bedrock were plotted on a base map. The elevation of the ground surface at each boring was taken from survey data or from a USGS topographic map when no survey data were available.

The cross sectoions were constructed by combining the topographic land surface, the top of the Cretaceous map, the top of the bedrock map, and the boring data. An attempt was made to locate the cross sections to best show the geology of the Aberdeen peninsula, however, density and quality of data were the primary controlling factors in locating the cross sections.

The cross sections show three major geologic divisions on APG-AA: the metamorphic bedrock, the sedimentary Cretaceous units, and the sedimentary Quaternary units. The bedrock are Paleozoic/Precambrian metamorphics usually overlain with a layer of saprolite or weathered bedrock. The saprolite consists of gray to green fine sands, silts, or clays varying in thickness from a few inches to over a hundred feet. There are no outcrops of the metamorphic bedrock on APG-AA. The metamorphic bedrock outcrops at the Fall Line to the north-northwest of APG-AA.

The Cretaceous sediments, as described earlier in this report, are in the Lower Potomac group, which includes the Patuxent, Arundel, and Patapasco Formations. The only Cretaceous outcrops on APG-AA are located along the northern boundary of APG-AA on the banks of Swan Creek. These outcrops consist of 10 to 30 ft of tan to white, fine to medium silty clayey sands and silts, and red to lavender clay located at the base of the banks. The Cretaceous units outcrop to the north-northwest of APG-AA, between the Fall Line and the APG-AA.

The top of the Cretaceous on APG-AA was mapped by Dunbar et al. (1997). The boring data used to construct the top of the Cretaceous map were limited to the Super Pond area and the area west of the Michaelsville-Old Baltimore Roads. The top of the Cretaceous was primarily identified by color change. The sediments overlying the Cretaceous sediments are usually dark or rust colored red, orange, or brown sands or silty sands, or dark brown, black, or olive colored clays or silts. The Cretaceous sediments are usually white, bright red, or lavender clays, or white to tan silts or sands.

The depth to the top of the Cretaceous units on APG-AA, as shown by boring data, varies from 40 to 70 ft in the cantonment area in the northern part of APG-AA and in an approximately 4,000-ft wide area underlying the Qt3 along the northwest boundary. The depth to the top of the Cretaceous to the east-southeast of these areas is about 200 to 250 ft, as shown by the borings along Michaelsville and Old Baltimore Roads. There are no deep boring data east of

Michaelsville Road, except for a few borings on Spesutie Island. Dunbar et al. (1997) identified three distinct changes in the top elevation of the Cretaceous units as erosional surfaces or terraces of the ancestral Susquehanna River. These three terraces were correlated with the Quaternary terraces, which had been mapped in other areas of the Chesapeake Bay.

The Cretaceous formations consist of interbedded sands, silts, and clays with some scattered lenses of sandy or clayey gravels. The sands vary from fine to medium, clean to clayey sands but are generally fine to medium, silty clayey sands. The similar depositional environments of the Patuxent, Arundel, and Patapasco Formations did not produce any lithologic units that could be correlated for any significant distance in the APG-AA area. Previous studies in this area of Maryland were not able to differentiate the Patuxent, Arundel, and Patapasco Formations. The Western Boundary Area RI (USAEDB 1996a, b) and Dunbar et al. (1997) reports were able to do some very limited correlations of the Cretaceous units along the western boundary of APG-AA with the help of boring and pollen data from APG-EA, boring data from the Western Boundary Area RI (USAEDB 1996), and some pollen age dates from the Western Boundary Area RI borings. Figures 36 and 47 show some sand and clay units in the upper 150 ft of the Cretaceous that were mapped from the area of the Harford County production wells HCP-5 and -6 along the APG-AA boundary into the APG-EA. The limited correlations were made in cross sections paralleling the strike of the Cretaceous units. Similar correlations could not be extended down dip.

The land surface of APG-AA consists of the three Quaternary terraces (Figure 44) which overly the Cretaceous units. The relationship of the three terraces to each other and the underlying Cretaceous units is best seen on cross section D-D' (Figure 49). The Qt1, the youngest of the terraces, is only present along the eastern edge of the Aberdeen peninsula. Boring data for this unit is limited to a few shallow water well logs and one deep boring (HA-DG-3) on Spesutie Island. The Qt1 terrace was identified primarily with topographic profiles. The surface is approximately el 10 to 15 ft msl.

The Qt2 terrace occupies approximately one-half of the APG-AA land surface; however, since most of the area is an impact zone, boring data are limited to the western edge of Qt2. Using the boring data, the Qt2 terrace deposits were divided into Units A, B, and C, with Unit A being the oldest. Unit A is the coarser-grained fluvial materials, consisting mostly of silts, sands, and gravels, deposited at the base of the terrace, on top of the eroded Cretaceous surface. Unit B is the finer-grained materials, consisting mostly of silts and clays with some scattered sand lenses, deposited as the stream valley was being filled. Unit C is made up of fluvial sediments, consisting mostly of interbedded silty clayey sands with some scattered gravels, deposited as the mouth of the stream prograded seaward over Unit B sediments. The base of the Qt2 terrace deposits is around elevation -140 to -160 ft msl. The Qt2 surface is a flat lying, poorly drained, swampy area at approximately el 25 to 30 ft msl.

The Qt3 terrace is located along the western edge of APG-AA. The terrace

deposits are composed primarily of 40 to 100 ft of medium to coarse sands, gravels and cobbles with some scattered silt and clay lenses, overlying finer-grained Cretaceous sands and clays. Borings along the western boundary fence line of APG-AA have encountered zones of clean gravel 10 to 30 ft thick in the Qt3. Boulders up to 12 in. in diameter can be seen at the surface. Outcrops of the Qt3 along the banks of Swan Creek consist of approximately 30 to 50 ft of sands and gravels with scattered boulders up to 3 ft in diameter. The surface of Qt3 slopes from approximately el 70 ft msl in the northwest corner of APG-AA to approximately 30 ft msl near the Bush River. The coarse-grained Qt3 deposits have resulted in a well drained land surface.

Groundwater

The boring data from the WBA study, the identification of the Quaternary terraces, and the collection of synoptic rounds of water level data have allowed the aquifers on APG-AA to be divided into several general zones. The water table aquifer can be divided into the Qt1, Qt2 Unit C, and Qt3 zones. There are very little data available for the Qt1 water table aquifer. Several supply wells for individual buildings on Spesutie Island have been installed in the upper 200 ft of the Qt1. These wells are screened in fine to medium silty sands. There are no data available for these wells.

The Qt2 Unit C water table aquifer consists of fine to medium silty sands with some scattered gravel lenses and with lenses of low permeable silts and clays scattered throughout. The water level data from the cluster wells at MLF show there are confined or semiconfined zones in Qt2 Unit C. The water level elevations in the deep wells of the MLF cluster wells, which are screened in a silty sand unit 100 to 130 ft below ground surface, are approximately 2 ft lower than the water table and intermediate depth wells. The permeability of Qt2 Unit C decreases with depth, as it grades downward into the finer-grained sediments of Qt2 Unit B.

The Qt3 water table aquifer is a highly permeable sandy, gravelly aquifer approximately 40 to 60 ft thick. The 11 City of Aberdeen production wells are screened primarily in the Qt3. Some of the CAP wells are partially screened in the fine Cretaceous sand at the base of the Qt3. The fine Cretaceous sands, which are only 5 to 10 ft thick, probably account for a small percentage of the total CAP well production. The 11 CAP wells have produced between 1 and 1.5 mgd from 1986 through 1997. Three of Harford County wells (HCP-5, -6 and -9) are screened in Cretaceous sands which are directly overlain by the Qt3 sands and gravels.

The Qt2 Unit A aquifer consists of sands and gravels located between the Qt2 Unit B aquitard and the finer grained Cretaceous sediments. There are very little aquifer data for Qt2 Unit A. Several of the APG-AA standby wells are screened across the Qt2 Unit B and A. Pump test data show each of these standby wells can produce 400 to 500 gpm; however, these wells have not been used.

The Cretaceous formations in the APG area of Maryland are generally

described as poor water-bearing units for production well purposes. The Cretaceous on APG-AA conforms to this general description of the Cretaceous aquifers in this area of Maryland. The interbedded sands, silts, and clays have formed aquifer units with variable permeabilities scattered throughout the Cretaceous formations. The Cretaceous sand lenses which were correlated along the western boundary are the only identified Cretaceous aquifers of any significance on APG-AA. All eight of the Harford County production wells are screened in these Cretaceous sands (Figures 37 and 42). HCP-1, -2, -3, -4, and -8 are screened in Cretaceous sands that are separated at each well from the Qt3 sands and gravels by clays 20 to 75 ft thick. HCP-5, -6, and -9 are screened in Cretaceous sands that are directly overlain by the Qt3 sands and gravels. As shown by the water table contour maps (Figures 64 through 67), the Harford County production wells are drawing significant amounts of water from the Qt3 aquifer. There are no data available to show how much of the total well production is being drawn from the Cretaceous or Qt3. The Maryland Geological Survey placed water level recorders in the shallow and deep wells in well cluster WB-MW5, which is located approximately 1,200 ft south of HCP-6, for a few weeks to determine if the Qt3 and Cretaceous aquifers were connected in that area. The wells had similar responses to pumping by the HCP wells, indicating the aquifers are well connected.

The water level data from the WBA monitor well and piezometer clusters show Qt3 aquifer and the permeable lenses in the Cretaceous units are well connected in some areas and poorly connected in other areas. The hydrographs in Figure 57 show the difference in water level elevation between the wells screened in the Qt3 and the Cretaceous units varies from a few inches to several feet. The Qt3 water levels vary anywhere from a few inches (cluster WB-MW-6) to several feet (cluster WB-MW-15) higher than the water levels in the wells screened in the Cretaceous sands. However, the water level in the Cretaceous screened well in cluster WB-MW-13 is 0.5 to 1 ft higher than the Qt3 well screened at the water table.

4 Data Gaps

The bulk of the geologic/hydrogeologic data on APG-AA are concentrated in the area between the western APG-AA boundary and the Old Baltimore and Michaelsville Roads. The area east-southeast of Old Baltimore and Michaelsville Roads is primarily test-firing ranges with very limited access. Geologic/hydrogeologic data from the range areas are limited to a few shallow monitor wells and borings. Additional geologic/hydrogeologic data from this area would be helpful in order to better define the:

a. Horizontal and vertical extent of the QT1 and QT2 Quaternary terraces
b. Lithologies of the QT1 and QT3 terraces
c. Groundwater flow
d. Cretaceous surface
e. Lithologies of the Cretaceous units

Surface water flow data on APG-AA are limited to data from two sites on Mosquito Creek. Base flows and runoff data should be collected from all the streams on APG-AA. Streamflow data could be used to delineate which segments of each stream are losing or gaining, and under what conditions. Comparison of the streamflow data and the synoptic water level data being collected could be used to determine the effect of the groundwater extraction systems on the Aberdeen Peninsula. The streamflow data would be useful to natural resource management and enhancement.

The existing 1927 soils map of APG-AA should be updated to better define the soil characteristics on APG-AA. This would aid in the understanding of the vertical movement of possible contaminants through the surficial soils.

Previous investigations in the APG-AA area have not been able to confidently differentiate the Cretaceous formations. Dunbar et al. (1997) used some very limited data to partially differentiate some of the Cretaceous formations. Clay mineralogy, heavy mineral, and pollen analyses of the Cretaceous materials may allow the identification and complete correlation of the Cretaceous formations. This could be very important in helping determine whether or not a possible route exists for contaminants to migrate under the Chesapeake Bay from APG-AA to the Delmarva Peninsula.

References

Allen, J.R.L. (1965). "A review of the origin and characteristics of recent alluvial sediments," *Sedimentology*, 5 (2), 91-180.

Bandoian, C.A., and Waldrop, R.T. (1985). "Hydrogeology of the proposed Perryman power plant," draft report, Environmental Resources Management, Inc., for the Power Plant Siting Program, State of Maryland Department of Natural Resources, 1-87.

Bennet, R.R., and Meyer, R.R. (1952). "Geology and ground water resources of the Baltimore area," *Mines and Water Resources Bulletin* 4, 68-72. Maryland Department of Geology.

Brown, P.M., Miller, J.A., and Swain, F.M. (1972). "Structural and stratigraphic framework and spatial distribution of permeability of the Atlantic coastal plain, North Carolina to New York," Professional Paper 796, *U.S. Geological Survey*.

Brush, Grace S., personal communication, 17 December 1993, Stanley Swartzel, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Clark, W.B. (1897). "Outline of present knowledge of the physical features of Maryland, embracing an account of the physiography, geology, and natural resources," *Maryland Geological Survey* 1, 1-86.

Clark, W.B. (1910). "Results of a recent investigation of the coastal plain formations in the area between Massachusetts and North Carolina," *Geological Society of America Bulletin* 20, 646-654.

Colman, S. M., and Halka, J. P. (1989). "Maps showing the Quaternary geology of the northern Maryland part of the Chesapeake Bay," MF-1948-D, *United States Geological Survey*.

Cooke, C.W. (1952). "Sedimentary deposits of Prince Georges County and the District of Columbia," *Mines and Water Resources Bulletin* 10, 27-48. Maryland Department of Geology.

Dames and Moore, Inc. (1972). "Perryman nuclear power plant, units 1 & 2," environmental report, Baltimore Gas and Electric Company, Baltimore, MD 2.4-1 -- 2.5-16.

Derryberry, N.A., Miller, S.P., and Breland, P.L. (1990). "RCRA facility assessment - other areas, Aberdeen Proving Ground," U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS (technical report in preparation).

Doering, J.A. (1960). "Quaternary surface formations of the southern part of the Atlantic Coastal Plain," *Journal of Geology* 68, 182-202.

Doyle, J.A., and Robbins, E.I. (1977). "Angiosperm pollen zonation of the continental Cretaceous of the Atlantic coastal plain and its application to deep wells in the Salisbury embayment," *Palynolgy* 1, 43-78.

Drummond, D.D., and Bloomquist, J.D. (1993). "Hydrogeology, water supply potential, and water quality of the Coastal Plain aquifers of Harford County, MD," *Maryland Geological Survey* 58, 1-160.

Dunbar, J.B., Blaes, M., Swartzel, S.M., Whitten, C.B., and Miller, S.P. (1997). "Geology and geomorphology of the Aberdeen Proving Ground, Aberdeen, Maryland," U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS (technical report in preparation).

Ebinger, M., personal communication, 17 September 1993, Kelly Blough, Advanced Sciences, Inc., Aberdeen, Maryland.

Edwards, J., Jr., and Hansen, H.J. (1979). "New data bearing on the structural significance of the upper Chesapeake Bay magnetic anomaly," *Maryland Geological Survey Report of Investigations* 30, 1-44.

Environmental Science and Engineering, Inc. (1981). "Installation assessment of Aberdeen Proving Ground-Aberdeen Area," Prepared for the U.S. Army Toxic and Hazardous Materials Agency, Environmental and Safety Division, Aberdeen Proving Ground, Aberdeen, MD.

General Physics Corporation (1993). "Final report for the fire training area/western boundary investigation," prepared for Directorate of Safety, Health, and Environment, Aberdeen Proving Ground, MD.

General Physics Corporation (1994). "APG Phillips Army airfield landfill draft final report," prepared for Directorate of Safety, Health, and Environment, Aberdeen Proving Ground, MD.

Geraghty and Miller, Inc. (1985). "Investigation of ground-water conditions at the Perryman power plant site, Harford County, Maryland," Baltimore Gas and Electric Company, Baltimore, MD.

Glaser, J.D. (1969). "Petrology and origin of Potomac and Magothy (Cretaceous) sediments, middle Atlantic coastal plain," *Maryland Geological Survey Report of Investigations* 11, 1-102.

Grim, R.E., and Allen, V.T. (1938). "Petrology of the Pennsylvanian underclays of Illinois," *Geological Society of America Bulletin* 49, 1485-1514.

Groot, J.J. (1955). "Sedimentary petrology of the Cretaceous sediments of northern Delaware in relation to paleographic problems," *Delaware Geological Survey Bulletin* 5, 1-56.

Groot, J.J., and Penny, J.S. (1960). "Plant microfossils and age of nonmarine Cretaceous sediments of Maryland and Delaware," *Micropaleontology* 6, 225-236.

Hack, J.T. (1955). "Geology of the Brandywine area and the origin of the upland of southern Maryland," Professional Paper 267A, *U.S. Geological Survey*.

Hack, J.T. (1957). "Submerged river system of Chesapeake Bay," *Geological Society of America Bulletin* 68 (7), 817-830.

Hansen, H.J. (1969). "Depositional environments of subsurface Potomac group in southern Maryland," *American Association of Petroleum Geologists Bulletin* 53 (9), 1923-1937.

Hansen, H.J. (1972). "A users guide for the artesian aquifers of the Maryland Coastal Plain, part two: aquifer characteristics," *Maryland Geological Survey*, 1-123.

Hansen, H.J., and Edwards, J. (1986). "The lithology and distribution of pre-Cretaceous basement rocks beneath the Maryland coastal plain," *Maryland Geological Survey Report of Investigations* (44), 11.

Jones, L., personal communication, 27 October 1993, Kelly Blough, Advanced Sciences, Inc., Aberdeen, Maryland.

Jordan, R.R. (1962). "Stratigraphy of the sedimentary rocks in Delaware," *Delaware Geological Survey Bulletin* 9, 8.

Jordan, R.R. (1968). "Observations on the distribution of sands within the Potomac formation of northern Delaware," *Southeastern Geology* 9 (1), 77-85.

Jordan, R.R. (1983). "Stratigraphic nomenclature of nonmarine Cretaceous rocks of inner margin of coastal plain in Delaware and adjacent states," *Delaware Geological Survey Report of Investigations* 37, 1-44.

Jordan, R.R., and Smith, R.V. (1983). "Atlantic coastal plain, correlation of stratigraphic units of North America (COSUNA) project," *American Association of Petroleum Geologists*.

LeGrand, H.E. (1961). "Summary of geology of Atlantic coastal plain," *American Association of Petroleum Geologists Bulletin* 45 (9), 1557-1571.

Luft, J., personal communication, 12 December 1993, Kelly Blough, Advanced Sciences, Inc., Aberdeen, Maryland.

Luft, J. (1991). Aberdeen Proving Ground Meteorological Laboratory; telephone communication with Kelly Blough, Advanced Sciences, Inc., November 12, Aberdeen, Maryland.

McGee, W.J. (1888). "Three formations of the middle Atlantic slope," *American Journal of Science* 3 (35), 120-143.

Maher, J.C. (1965). "Correlation of subsurface Mesozoic and Cenozoic rocks along the Atlantic coast," *American Association of Petroleum Geologists*, 1-18.

Metcalf and Eddy (1996). "Michaelsville landfill operable unit two, Aberdeen Proving Ground, Maryland," prepared for Directorate of Safety, Health, and Environment, Aberdeen Proving Ground, MD, and Lockheed Martin Energy Systems, Inc., Oak Ridge, TN.

Miller, B.L., and Bibbins, A. (1904). "Map of Harford County," *Maryland Geological Survey*.

Miller, R.D., Xia, J., Anderson, J.M., Laflen, D.R., and Marcus, S. (1995). "High resolution seismic reflection profiling at Aberdeen Proving ground, Maryland," Kansas Geological Survey Report prepared for U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Minard, J.P., Sohl, N.F., and Owens, J.P. (1977). "Reintroduction of the Severn formation (Upper Cretaceous) to replace the Monmouth formation in Maryland, Changes in stratigraphic nomenclature by the U.S. Geological Survey, 1976," *U.S. Geological Survey Bulletin* 1435-A, A132-A133.

Moorsehead-Siddiqui and Associates (1983). "An evaluation of existing wells and water supply potential for Aberdeen Proving Ground, MD," prepared for U.S. Army Engineering District Baltimore, MD, Aberdeen Proving Ground, Aberdeen, MD.

Otton, E.G. (1955). "Ground-water resources: The water resources of the southern Maryland Coastal Plain," *Mines and Water Resources Bulletin* 15, 99. Maryland Department of Geology

Otton, E.G., and Mandle, R.J. (1984). "Hydrology of the Upper Chesapeake

Bay area, Maryland, with emphasis on aquifers in the Potomac group," *Maryland Geological Survey Report of Investigations* 39, 1-62.

Owens, J.P. (1969). "Coastal plain rocks of Harford county: The Geology of Harford County, Maryland," *Maryland Geological Survey*, 77-111.

Owens, J. P., and Denny, C. S. (1979). "Upper Cenozoic deposits of the central Delmarva Peninsula, Maryland and Delaware," Professional Paper 1067-A, *U. S. Geological Survey*, A24-A26.

Rafalko, L.G. and Keating, R.W. (1990). "Perryman groundwater report," draft technical memorandum prepared by Environmental Resources Management, Inc., for the Maryland Department of Natural Resources Power Plant and Environmental Review Division, Baltimore, MD, 1-1 -- 7-9.

Richards, H.G. (1948). "Studies on the subsurface geology and paleontology of the Atlantic coastal plain," *Philadelphia Academy of Natural Sciences Proceedings* 100, 39-76.

Shattuck, G.B. (1902). "The geology of the coastal plain formations," *Maryland Geological Survey*, 149-179.

Shultz, L.G. (1958). "Petrology of underclays," *Geological Society of America Bulletin* 69, 363-402.

Sisson, P.A. (1985). "Climatic summary for Aberdeen Proving Ground, Maryland," reference Pamphlet No. 3, Atmospheric Sciences Laboratory, Aberdeen Proving Ground, MD.

Southwick, D. L. and Owens, J. P. (1968). "Geologic map of Harford County," *Maryland Geological Survey*.

Spoljaric, N. (1967). "Quantitative lithofacies analysis of the Potomac formation, Delaware," *Delaware Geological Survey Report of Investigations* 12, 1-26.

Sundstrom, R.W. and others. (1967). "The availability of groundwater in the Potomac formation in the Chesapeake and Delaware Canal area, Delaware," University of Delaware, Water Resources Center, Newark, DE, 17-24.

Tamers, M., personal communication, 20 May 1993, Stanley Swartzel, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

U.S. Army Engineer District, Baltimore (1980). "Hydrogeology of the Michaelsville and Phillips Army Airfield Landfills," Aberdeen Proving Ground, MD.

U.S. Army Engineer District, Baltimore (1990). "Hydrogeologic investigation,

environmental reconnaissance sampling wells, U.S. Army Combat Systems Test Activity, Aberdeen Proving Ground, Maryland," prepared for U.S. Army Combat Systems Test Activity, Aberdeen Proving Ground, MD, 1-5.

U.S. Army Engineer District, Baltimore. (1996a). "Conceptual geologic interpretation for Aberdeen Area, Aberdeen Proving Ground, Maryland," prepared for Directorate of Department of Safety, Health, and Environment, Aberdeen Proving Ground, MD.

U.S. Army Engineer District, Baltimore. (1996b). "Phase I field investigation western boundary study area, Aberdeen Area, Aberdeen Proving Ground, Maryland," prepared for Directorate of Department of Safety, Health, and Environment, Aberdeen Proving Ground, MD.

U.S. Army Engineer District, Baltimore. (1996c). "Phase II field investigation western boundary study area, Aberdeen Area, Aberdeen Proving Ground, Maryland," prepared for Directorate of Department of Safety, Health and Environment, Aberdeen Proving Ground, MD.

U.S. Army Environmental Hygiene Agency. (1988). "Geohydrologic study no. 38-26-0866-88, Phillips Army Airfield Landfill, Aberdeen Proving Ground, Maryland," Aberdeen Proving Ground, MD.

U.S. Department of Agriculture. (1927). "Soil survey of Harford County, Maryland," Number 26, United States Department of Agriculture, Bureau of Chemistry and Soils.

U.S. Department of Agriculture. (1975). "Soil survey of Harford County, Maryland," United States Department of Agriculture, Soil Conservation Service.

U.S. Geological Survey. (1967). "Engineering geology of the northeast corridor Washington, D.C. to Boston, Massachusetts, coastal plain and surficial deposits," *U.S. Geological Survey Miscellaneous Investigations Map I-514-B*.

Vroblesky, D. A., and Fleck, W.B. (1991). "Hydrogeologic framework of the coastal plain of Maryland, Delaware, and the District of Columbia," Professional Paper 1404-E, *U.S. Geological Survey*, 1-41.

Whitman, Requardt and Associates (1976). "Harford County, Maryland, Perryman test well program and report on development of additional well water supply," prepared for Harford County, MD, 1-14.

Whitten, C.B., Miller, S.P., Derryberry, N.A., and Wade, R. (1992). "Aberdeen area fire training area hydrologic assessment Aberdeen Proving Ground", Technical Report GL-92-20, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

List of Abbreviations

AEC	U.S. Army Environmental Center
AEHA	U.S. Army Environmental Hygiene Agency
AFTA	Aberdeen Fire Training Area
APG	Aberdeen Proving Ground
APG-AA	Aberdeen Proving Ground - Aberdeen Area
APG-EA	Aberdeen Proving Ground - Edgewood Area
ASI	Advanced Sciences, Inc.
BG&E	Baltimore Gas & Electric
CAP	City of Aberdeen Production well
CDP	common data point
CSTA (ATC)	U.S. Army Combat Systems Test Activity (changed name to Aberdeen Test Center in 1995)
EEGD	Earthquake Engineering and Geosciences Division
el	elevation
EGB	Engineering Geology Branch
ESE	Environmental Science and Engineering, Inc.
ft	feet
ft/mi	feet per mile
GL	Geotechnical Laboratory
gpm	gallons per minute
GP	General Physics, Inc.
GIS	Geographical Information System
HCP	Harford County Production well
in.	inch
IRDMIS	Installation Restoration Management Information System
mya	millions of years ago
M&E	Metcalf and Eddy
mgd	millions of gallons per day
MLF	Michaelsville Landfill
msl	mean sea level
NAVD88	North American Vertical Datum of 1988
NAD83	North American Horizontal Datum of 1983
PAAF	Phillips Army Airfield
PAAFLF	Phillips Army Airfield Landfill
Qt1	Quaternary terrace 1
Qt2	Quaternary terrace 2
Qt3	Quaternary terrace 3
U.S.	United States

USAEDB	U.S. Army Engineers District, Baltimore
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WBA	Western Boundary Area
WBA RI	Western Boundary Area Remedial Investigation
WES	U.S. Army Engineer Waterways Experiment Station
yd	yard

Appendix A
Rainfall Data

Rainfall data from the Department of the Air Force, Air Force Climatology Center, 151 Patton Avenue, Room 120, Asheville, NC, 28801-5002.

DAILY RAINFALL FOR JANUARY 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57		66	67	68	69	70	71
1	no	T	T		0.10	T		0.80				no	T	0.50			n/d
2	no		0.40		0.53	0.80		0.16				no					n/d
3	no		0.24	T	0.10	0.60	T					no				T	n/d
4	no			0.50	0.40							no		T			1.30
5	no	1.68			0.37		T	0.10				no					0.69
6	no	0.65	T			0.27	T	0.50		0.30		no		T			
7	no		T	0.32		0.21				0.10		no		0.26	T	0.28	
8	no				T	0.83						no	0.40				
9	no		T		T	1.30	0.20	0.80	0.90	0.30		no			T		
10	no		0.30		1.24	0.42	0.23		0.12	0.16		no		T			
11	no			0.20		0.13	0.32		0.42			no					
12	no	0.70	0.20			T			0.80			no				T	
13	no		0.10					0.10	T	0.16		no					T
14	no		0.70	0.34	T		0.37			0.22		no	0.70	1.50			0.33
15	no			0.46	0.20		0.40	0.50		0.13		no		0.10			
16	no		T			T	0.26		T	0.30		no		T			
17	no	T	T		0.52	T			0.40			no				T	T
18	no	T	0.70		0.30	0.38				T		no			0.87	0.37	
19	no	0.50	0.10		0.30				0.21			no	0.30		0.10		
20	no				0.15		T		0.10			no				0.20	
21	no	0.83	T			0.27	T			0.12		no			0.70	T	
22	no	0.52			0.69		0.31	0.70		0.70		no					
23	no	0.44		0.13						0.41		no		0.17	0.17	T	
24	no	0.15	T	0.45		1.50	T					no			0.14		
25	no	0.30			T	0.10		T	T	T		no			T	0.10	0.42
26	no	0.50	T		1.50			T				no					0.20
27	no	0.47	0.11	T	0.29	T	T			T		no	0.92			T	
28	no	0.53	0.40	0.80	0.82	0.10	T			0.17		no	T	0.10			
29	no	T	0.10	0.25					0.32	0.15		no			0.10	T	
30	no		0.39	0.10				T	0.44			no		0.10	0.12		n/d
31	no	0.34	0.38	0.77		T				0.26		no	T	0.14	0.60		
Total		7.61	4.12	4.32	7.51	6.91	2.09	3.66	3.71	3.48			2.32	2.87	2.80	0.95	2.94

DAY	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1	0.68	T	0.25	0.16	2.37		0.05									n/d	n/d	n/d	n/d				n/d	n/d	n/d
2							T	1.54		0.12				0.16		0.98	n/d	n/d	0.87				n/d	1.36	0.54
3	0.90		0.15	T	0.29									0.22	0.26		n/d	0.22			T		0.05		0.37
4	0.59	0.34	0.51						T		2.16		T	0.12			0.24	0.05	0.04			T	0.92	0.05	
5										T		0.09		n/d								1.03	T	T	n/d
6				T								0.07		n/d	0.02			0.35	n/d		T		T		n/d
7				0.45	0.32	0.24			0.14	0.10	1.00			0.19					n/d	0.86			0.32	n/d	n/d
8					0.45		n/d	0.45									0.47		0.36	T		0.25	n/d	n/d	n/d
9	0.69		0.48	0.48			1.38		0.08									T	0.31	0.28	0.12	n/d	n/d	n/d	n/d
10	0.60		0.26			0.62						0.48	0.04	T		n/d					T	n/d	0.54	0.34	n/d
11			0.44		0.10			T				0.31	0.49	0.03		n/d				0.21		0.19	n/d	T	1.49
12	0.14							0.12	0.24							0.14		1.07		1.35		0.21	0.46	0.02	n/d
13	0.20			0.76			0.20	n/d			0.36				T		0.03	T	n/d			0.18	T	1.79	n/d
14				T	0.09	0.22			0.49		0.27				T			n/d	n/d		0.40		0.01		n/d
15										0.10	0.03					0.03		n/d	n/d				n/d		n/d
16						0.42				T		0.04	0.08				n/d	n/d	0.10	0.38	T		n/d		0.64
17							0.36	0.05					T	0.23		n/d	n/d	0.77		0.21			n/d		0.01
18				0.59			1.05				0.08		0.33	T		n/d	n/d						1.30		
19	0.13	0.19							0.34		T		T	n/d		n/d	0.34			n/d					1.12
20	T			1.00	0.12		0.98	0.32			0.03			n/d		1.69	0.92		n/d	n/d			T		
21			0.53	0.02	0.03			2.10		0.07	0.11			0.05			T		n/d	0.13		T			
22	0.15	0.42			T			T	0.09			n/d				n/d			0.14			0.35			
23		T							0.21		0.68	n/d				0.82	n/d				0.14			T	
24	T		0.07					1.17				1.39	T				n/d		1.00		0.21	n/d			0.24
25		T	0.20	0.23		0.14	1.49	0.24	0.02		T		0.14	T	n/d	n/d	0.35	T	0.94		n/d	0.05		T	0.04
26				0.03	0.54		0.87	T			0.02			n/d	n/d	n/d	0.42	0.13	1.12		0.06		0.48	T	
27	0.32	0.70	0.04		1.39									n/d	1.90	0.29	T		n/d				T		n/d
28		0.40	T	T	0.45			0.15						0.08				n/d	n/d				1.51	0.58	n/d
29		0.76		T		T				T					0.18			n/d	0.15						0.64
30					T						0.10	n/d	T			0.18		0.22	0.80	T					
31				0.22				0.03	T		0.04	0.22	0.08	0.24						1.00			T		T
Total	4.40	2.81	2.93	3.94	6.15	1.64	6.38	6.17	1.61	0.39	4.88	2.60	1.16	1.32	2.36	4.13	2.77	2.81	5.83	4.42	0.93	2.26	5.59	4.14	5.09

No climatic data were being collected during the years from 1958 through 1965.

T - Trace (less than 0.005 inches)

no - no climatic data were collected in January 1948 and 1966

n/d - no rainfall data for this day

Rainfall data are in inches.

DAILY RAINFALL FOR FEBRUARY 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57		66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1	no		0.59	0.55		0.60		0.60		0.56		no		0.10	T		T	0.11	0.03												0.56	n/d		T					T	T		
2	no		0.24		T			0.30	0.82			no	T	0.36	0.22	0.11		0.69	1.20		0.06	0.89		0.04			0.81		0.39		n/d	n/d	T	0.27								0.06
3	no				0.60		T			0.60		no	0.23	T	T	0.47		0.80				T	T					1.14	0.13	T	n/d	0.03		0.18	0.40	n/d						n/d
4	no	0.44			1.40				0.41	T		no				T	0.70									T		T		n/d	0.57	0.50		0.38	n/d	n/d						n/d
5	no									0.11		no					0.40				0.47									n/d	T	0.15			n/d	0.45						0.34
6	no		0.60					1.40	0.76	0.50		no							T	T	0.03	0.07		0.40					n/d	0.33	0.19				0.25		0.17		n/d			
7	no	0.37		1.70		1.10		0.12	0.50	T		no	0.90				S		0.23	0.36	T				0.19	T			0.60			0.41			T	T	0.22		n/d			
8	no						0.11					no					1.48		0.42	0.22					0.08														0.03	0.16	0.04	0.12
9	no		0.84				T		T	0.54		no			0.49	T	0.20		T						T		0.36	0.49					T			T		n/d		0.87	0.34	0.14
10	no	0.55	0.21							0.34		no	0.18	T		1.35																T				n/d		0.04		T	T	
11	no		T		T	0.10		0.47	0.36			no				T				T		T					0.64		n/d	n/d		0.32				n/d				n/d		
12	no					T			T			no						1.42			0.50				0.29		0.07		n/d	n/d	1.31	T	T	1.83		0.48			0.27	n/d		
13	no	T	0.42			T			T	T		no					1.15								0.07				n/d	0.05	T		T	n/d	T			0.08	n/d	n/d		
14	no		0.71	T			T		T	0.53		no				0.25			0.32					0.22					1.10	0.26		1.00		n/d	0.75		0.35	0.09	n/d	1.29	0.01	0.01
15	no	0.13	0.40			1.30			0.35	0.50		no				0.50			0.33				T		1.00					1.94		n/d		n/d	0.22	T		n/d	n/d			0.04
16	no	0.72		T	0.74		T			T		no						0.26	0.04					T	0.03	0.14		0.02		0.04		n/d	n/d	0.45	0.17	0.03	n/d	n/d	1.35		0.05	0.27
17	no		T	0.80	0.68		0.17	0.10	0.27	T		no	0.11			T	0.40	0.40	T		0.09	0.06		T				0.27	1.00	0.02		n/d					n/d	0.95	T		T	
18	no								0.68			no	0.12		0.30			0.67		0.02	0.17	0.26						0.72		n/d		0.78			n/d		n/d	0.34				
19	no	0.16	0.10	0.30						T		no								0.06					1.04		T	0.53		n/d		T		0.08	n/d		0.15	0.03				
20	no	0.28		0.40		T	0.10					no	0.10	T	0.13					0.05							0.27			n/d		0.02		n/d	n/d		1.00	0.05	n/d	n/d	0.06	T
21	no			1.70		0.27	0.11		T			no	0.13	T											0.13					0.03		0.03		n/d	0.99				n/d	n/d	0.86	0.69
22	no	0.52	0.30	T				0.16				no					1.34	T	0.09	0.10						0.27						n/d		0.87	0.37	0.10		n/d	0.59	0.05		T
23	no		0.70					0.56				no			0.97		0.78	0.23			0.70				0.02		0.68			T		n/d	1.02	T	T	0.20		n/d		1.05		0.17
24	no		T				T	0.13	0.13			no	T		0.20						0.25		0.18		1.40		0.52			0.89		0.23		0.03	T	n/d		0.09		0.37	T	
25	no	T					T		0.90	T		no			T	T		0.48		0.23	0.12		0.42		1.90	0.19	T					0.07		T	n/d	n/d		0.04				
26	no			T			0.13			0.40		no			T										0.17						T				0.15	0.12	T	0.74	0.16			T
27	no	T	T					0.90		0.10		no					0.34													T	T	0.04			T	T					T	T
28	no	0.54	0.10	T			T		T	0.36		no	T			T							0.02			0.08				0.39					T							
29	no	***	***	***		***	***	***		***		***	***	0.20	***	***	***		***	***	***		***	***	***	T	***	***	***	0.04	***	***	***	T	***	***	***		***	***	***	
Total		3.71	5.21	5.45	3.42	3.37	0.62	4.74	5.18	4.54			1.77	0.66	2.31	2.68	6.79	5.06	2.66	1.04	2.39	1.28	0.62	0.66	6.32	0.68	3.35	3.17	3.22	3.99	2.63	3.58	1.02	4.09	3.30	1.38	1.89	2.45	2.40	3.79	1.36	1.84

No climatic data were being collected during the years from 1958 through 1965.

*** — not leap year (no 29 February)

T - Trace (less than 0.005 inches)

no - no climatic data were collected in February 1948 and 1966

n/d - no rainfall data for this day

Rainfall data are in inches.

DAILY RAINFALL FOR MARCH 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57		66	67	68	69	70	71	72	73	74	75	76
1	no		0.30	0.15	0.43		1.17	0.28		0.44		no		0.25	T							
2	no		T		T	T			0.11	0.20		no			0.17			0.69				T
3	no			0.80	0.10	0.70	0.41	0.20	T			no			T	0.10	0.44		0.43			T
4	no			0.23	0.30	0.40	T	1.22				no				0.80	0.55	0.30	0.09			0.11
5	no				T			0.20				no	0.20			0.26			T			
6	no	T				T		0.86	T	T		no	0.40		T				0.07	T		
7	no		T	T	T			0.10	0.36	0.70		no	2.45		0.31			T	T	0.07	T	
8	no		0.80			0.41			0.58	1.00		no							0.36	T		
9	no			T		T				0.80		no		0.40				T				0.24
10	no	T			0.12							no		0.70							0.07	0.19
11	no	T	0.53		1.52	0.20	0.10	0.20	0.37			no	0.24						T		0.1	
12	no		0.30			0.32	T	T	0.14			no		1.20		0.23		0.40			0.39	T
13	no		0.42	0.10	0.40	0.16	0.14		0.22			no	T	1.20		0.30		0.35			0.04	0.09
14	no			0.54	T		0.56		1.59			no	T			T					0.82	0
15	no	T		T		1.44		0.39		1.30		no	0.55				T	T	0.02			
16	no		T					0.10	0.61	0.30		no	T					1.29	0.02	0.26		0.26
17	no											no	T	1.46					0.53	0.07	T	T
18	no	0.66	T	T	T	0.40		0.20	0.61	T		no		1.10		0.31						
19	no			1.10	0.99	T	0.39		0.12	0.23		no				T	0.61				1.22	
20	no		0.40	0.15			0.13			0.50		no				0.31					0.08	
21	no		0.71	0.30				0.57				no	0.27	T				0.57	T	0.9		T
22	no	T	1.39	0.10	0.40			0.94				no	T			0.56	T		T			
23	no	1.75	0.20		0.37	T	T					no	0.11	0.52	T	T	0.17					
24	no		T	T	0.26	0.63	T	T	T			no			0.90	T					0.36	
25	no	T	T			0.57	0.64	0.20		T		no			0.48						0.31	T
26	no	T	0.20			T	0.30	0.60	T	T		no			T				1.44			
27	no	T	T		0.12					0.80		no				0.24			0.16			
28	no	T	0.44	T	0.15	T			0.12	T		no										
29	no		0.22	1.10	0.70				0.18	0.20		no	0.35			0.92		T		0.18		
30	no			0.36	T		T		T			no			T	T			0.23		0.22	0.02
31	no	0.52		T			0.16		T			no		T		0.15		0.70	0.46	1.85	0.28	0.1
Total		2.93	5.91	4.93	5.86	5.23	4.00	6.06	5.01	6.47			4.57	6.83	1.86	4.18	1.77	4.30	3.81	3.33	3.89	1.01

DAY	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1		T	T		0.02		0.19				0.89				n/d			0.02	0.40	
2			0.03	0.09			0.37				T			T	n/d			0.64	0.79	0.05
3		0.29				T		n/d			T	T	T		n/d			0.42		
4	0.54					0.03		n/d	0.02	T		0.85	n/d		0.83		1.22			
5	T		0.47	0.22	0.79			0.47	T				n/d				0.34			
6			0.17		0.02	n/d	n/d	0.19		T		n/d	0.91	T	0.02	0.04				0.27
7				T		n/d	0.27					0.02	0.27		0.16	1.19		T		0.76
8		0.07				0.85	1.02	T	0.12								T	0.14		0.09
9		0.03		0.07		T	0.17	0.24			T	T		T			T	0.07		
10		0.02			T		0.64					T		n/d		T	0.01	1.48		
11			0.54	0.19	0.11	T	0.04		T	T				n/d		0.37				
12					T	0.16			T	T				0.11		T				
13	1			0.37			n/d	0.08		0.21					0.02		n/d			
14	0.32	0.27	0.07	0.92			0.06	T		0.52		T			0.33		n/d		0.31	
15						T	0.02			n/d					0.02		1.93	0.04	T	0.34
16		0.49			0.18	0.23				n/d		T			n/d	T				T
17		0.09		0.24		0.24	T			0.23				n/d	n/d	T	1.34			
18	0.52			0.15			0.57					T		n/d	0.98	T	0.12	T		
19					T			T		T				1.02	T	0.69		n/d		T
20	0.22				T		n/d		T				T	0.08		T	n/d	n/d		0.89
21				0.89			2.07	0.27					0.61		T	n/d	n/d	0.15	T	
22	1.64	0.09					T	T	T						0.02	n/d	0.11	0.52		
23								T	n/d						n/d	0.23	0.12		0.02	
24				T				n/d	n/d				1.68	n/d	n/d		1.27	T		
25		0.4	0.67	0.47	T			n/d	0.91		T		n/d	n/d	1.09			0.07	n/d	
26		2.75	T			0.14		0.75			T	n/d	n/d	0.26		0.23		n/d	n/d	
27		0.45			T		n/d			T		n/d	1.00		0.16	1.42	n/d	n/d	0.01	
28	0.13						1.89	0.77				1.20					n/d	2.01	T	0.22
29			T					1.17	0.34				T	T	0.22		0.18	0.78	T	1.62
30					0.27				0.61		0.11		0.08	0.36	n/d		0.01			
31				2.21		0.31			0.38		0.49		0.73		n/d	0.07		T		
Total	4.37	4.95	1.95	5.82	1.39	1.96	7.31	3.94	2.38	0.96	1.49	2.07	5.28	1.83	3.85	4.24	6.65	6.34	1.53	4.24

No climatic data were being collected during the years from 1958 through 1965.

T - Trace (less than 0.005 inches)

no - no climatic data were collected in March 1948 and 1966

n/d - no rainfall data for this day

Rainfall data are in inches.

DAILY RAINFALL FOR APRIL 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57		66	67	68	69	70	71	72	73	74
1	no	0.28	T	T	T	0.10	T			0.16		no		T					1.00	T
2	no			0.88	0.20	T			T	1.16		no			T	2.70	0.11		1.04	0.08
3	no	T	T	0.12					0.27			no			0.70		0.12	0.22		
4	no	T				0.23				0.14		no		T		T			0.96	0.39
5	no	0.50	0.40		1.80		0.20			1.24		no	0.40	T	0.40					0.36
6	no	0.72			T	0.29	0.12	0.26	0.48	0.46		no	T			T	0.42	0.23		
7	no	T			T	0.50	T		0.70			no	0.39			0.12	1.10	0.14		
8	no	T		T			0.10		0.40	0.33		no		0.50					0.95	0.19
9	no			T		T				T		no				T				1.16
10	no			0.18		0.30						no	T		T			0.60	0.42	0.05
11	no	T	0.70		T		0.90					no			0.17					
12	no		T	0.23		0.71		1.40		T		no						1.10	T	
13	no	0.77	T	T	0.28	0.57		T		T		no								0.54
14	no	T		T	0.80	T		0.98				no				1.20				
15	no				0.39		0.20	T	0.11			no		T	T	0.69				
16	no			T	0.80	0.50	0.14		0.46			no			0.58			1.42		
17	no						0.62	0.40	T	0.20		no	0.60		T		0.30			
18	no	0.47				0.31			0.10	0.70		no			0.27	T			0.05	
19	no		T	0.11				T				no			0.14	T		T		T
20	no		0.20			T		0.10				no				0.78				
21	no		0.10					0.70		T		no		T		T		1.10		
22	no	0.51		0.38				0.32	T			no	T	0.14	0.22		T			
23	no	T	0.17	0.17	0.50	T	0.70	T	T	0.17		no			T	0.14		0.33	0.24	0.49
24	no	0.11	0.60		0.56		0.50	0.10	0.16	T		no	0.14	0.82	T	0.33			0.18	
25	no		0.20		0.75		0.20	0.39		T		no		0.25					0.24	
26	no		0.11	T	1.16	0.98	T	0.29	0.16	T		no	0.14	0.50			T		1.39	
27	no	0.50	T		1.77		0.66	T				no	0.90			0.40			0.36	
28	no		0.20		0.56	T	T		T			no					0.20		0.08	
29	no			0.16	0.10	T		0.50	0.30	T		no			0.10		0.40			
30	no		0.70			0.90		T				no		0.13	T				T	
Total		3.86	3.38	2.23	9.67	5.39	4.34	5.44	3.14	4.56			2.57	2.34	2.58	6.36	2.65	5.14	6.91	3.26

DAY	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1		1.91			0.20	0.24	0.03	0.12			0.14				n/d	n/d	0.26	T	0.60		n/d	0.21
2		0.03	1.25		0.07		0.33								n/d	0.40		T	0.46	n/d	0.12	0.59
3	0.27			0.05	0.29						0.03				0.37	0.64		T		n/d	0.11	
4		0.45	0.25	0.10	0.19	0.29			0.89	0.56	T	0.02	n/d	0.11		T				0.02	T	
5			1.19		0.16					0.58		n/d	n/d		T	T	0.02		T			T
6			0.09				0.37	1.89		0.34		n/d	1.01		0.66	0.12	T			0.14	0.65	n/d
7				0.08				T	0.12			0.20	T	0.68	0.02	n/d				0.30		n/d
8		T				T			0.38		0.04	0.31		0.18	n/d	n/d						0.29
9					0.67	0.42	0.21	0.21			T	T			n/d	0.34		T		n/d		0.42
10				T	0.40	0.09	T					T			0.42	T		0.23	n/d	n/d		0.18
11									2.46		0.06	T				0.11		n/d	n/d	0.26	T	T
12				0.07	0.26							n/d	T					n/d	2.17	T	T	
13					T		1.83	0.02		0.02		n/d	T				n/d	1.00		0.29		
14						0.19	0.82	0.03		n/d		0.05				n/d	n/d			0.43	0.05	
15	0.29					0.09	0.08		0.65	n/d	0.02	0.08	T	T	n/d	n/d	0.98		T		n/d	
16	0.06				0.31					0.96	T	0.86	T	n/d	n/d	1.01	T	0.07	0.88	n/d	n/d	1.94
17							0.02			0.25	0.05	0.48	0.15	n/d	0.77	0.05		1.00	T	n/d	0.33	
18	0.06								1.83	0.42	T	0.05		0.11		T	T	n/d		0.45		
19	0.17			0.52				1.05	T	T				0.21	0.48			n/d			T	
20				0.59			0.12		0.04				T				n/d	0.38		T		
21	T	0.36						T		n/d		0.13				n/d	n/d	0.04	T		T	
22		T								n/d		0.18				n/d	0.82	0.41	0.85		n/d	
23							0.04			0.35		0.08	T	n/d		0.31		1.00			n/d	
24	0.03						0.14			0.08	0.03		0.06	n/d			0.45				0.78	0.23
25	0.77		0.60			0.09			2.07	T	0.08		n/d	0.16			0.02	n/d			0.62	
26	1.25	0.32	0.29		0.09			1.52	0.04				n/d					n/d	0.46		0.01	0.07
27				T	0.69		0.02	0.44	T				0.18					0.43	0.02	n/d		n/d
28						1.49		0.73					T	1.35		n/d				0.44	0.08	n/d
29	0.06		0.26		0.10	0.24	1.23			T					n/d	n/d	T	T				0.09
30						0.37	0.06			0.07		T			n/d	0.87		T				0.43
Total	2.96	3.07	3.93	1.41	3.43	3.51	5.30	6.01	8.48	3.63	0.45	2.44	1.40	2.80	2.72	3.85	2.55	4.56	5.44	2.33	2.75	4.45

No climatic data were being collected during the years from 1958 through 1965.

T - Trace (less than 0.005 inches) | no - no climatic data were collected in April 1949 and 1966 | n/d - no rainfall data for this day | Rainfall data are in inches.

DAILY RAINFALL FOR MAY 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57		66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1	no	0.30	0.13			0.30		0.57				no									0.87					0.74	0.11			0.66		T		n/d	n/d	T		T		n/d		0.24
2	no	0.94	0.30						0.32			no					T	0.88			0.02	1.69	0.12			T							n/d	0.05	1.59		0.08			n/d		0.01
3	no	0.20	0.37	0.18			1.18		0.10			no	0.39	0.10		0.30	T	0.10	0.66	0.70					T	0.34				0.02	1.67		n/d	T		1.00	T	1.00			0.52	0.13
4	no					0.20	0.30	T	T			no		T		0.17	0.20		0.06		0.90		0.17	0.29	0.04		0.70		0.15	1.42			1.25	0.09		0.04	n/d			0.23	0.46	0.01
5	no		0.20	T		0.30						no		0.10							0.86		0.04	1.02	0.12					n/d			T	0.75	0.57	n/d	n/d	0.02	0.07	0.26		n/d
6	no		0.30	0.10		0.33			0.20	T		no	T	0.40		T	0.35			0.05	T		0.17				T			n/d				0.79	1.40	n/d	1.20		0.21	0.02	n/d	0.79
7	no	0.98				0.20	0.20		0.30			no	1.66				T			0.14	0.12	0.02	0.40							0.10	T			n/d		0.44	0.29			n/d	n/d	T
8	no				0.20	0.70	0.30	T				no	T		T	T	0.52	0.77	T					0.18		0.17		0.27		0.08			T	n/d	T			1.17		n/d	0.23	0.45
9	no	0.24	0.20			T	T					no	0.30		1.19			0.40	0.68	0.25				1.12					0.05	0.45				0.10			T	n/d		0.99		1.17
10	no	0.35	T	T	0.50		0.17	T	0.10			no								0.32				0.84										0.07	1.12	1.61		n/d			0.27	0.03
11	no		T	0.73	0.16					T		no	0.30	0.50								T					0.92							0.44	0.14	0.28		0.20			0.94	n/d
12	no		0.10		0.30				T			no		0.50			0.60					0.33			0.87	0.09	0.29			0.06				0.27	T					0.09	0.58	n/d
13	no		T		T	0.13		0.30	0.14	0.12		no				T	1.26	0.69		1.30	1.79			0.42	0.33	0.12		T			0.09		0.19		n/d	n/d	T		0.83			0.79
14	no	T	T			0.30	T	0.16	T	1.33		no	0.17			0.40	0.20		T		0.16	T		1.60	0.09							T			n/d	0.84	0.37					
15	no	0.10	1.20		T	T	0.26		T	T		no	0.70					0.16	0.21					0.40			0.33				0.02		0.64		0.06			T	n/d			
16	no		T		T	0.60			T			no	1.12	0.15			1.32		0.09		0.57	0.09		0.43					1.42		0.03		n/d		0.62	T		0.42	n/d	0.66		0.34
17	no		0.30		T	0.55	0.10		T			no	T	T		0.46			0.12			T		0.06					0.37		0.77		n/d	0.02	0.17	0.02	T	n/d	0.34	T		
18	no		1.79		0.20					0.24		no		T				T	0.07	0.63		1.02		0.42	0.04		0.57	0.05					0.27	2.10		0.31	n/d	0.03	0.23		T	
19	no		0.20	T	0.90	0.15	T		T	0.16		no		0.10	0.26							0.19	0.05		0.31	0.77	0.11	1.00	T	n/d			0.30	1.47		n/d	n/d	T	0.16	0.02	1.80	
20	no	T		0.10	0.63	T	0.57			0.37		no	0.35	0.50	0.10			0.90	0.49							0.62	0.09	0.36	0.50	n/d	0.12	0.18	0.97	0.10		n/d	0.35		0.19	0.27	n/d	
21	no	T		T		T	0.10			0.50		no		0.22			0.16		0.02		T				T	0.27		0.21		0.04		0.74	0.12	n/d		0.16					n/d	
22	no	1.24		0.10		0.36	T	0.10	0.19			no	0.16	T			T				0.27				0.02	0.12		n/d			0.03	0.49	T	n/d		T					n/d	0.14
23	no	0.70	0.43	1.30		T		T	0.10	T		no		0.26					0.25	0.72	T				0.21			n/d	1.65	T	1.10		n/d	0.07	1.32			n/d			0.20	
24	no	0.76	T	0.13	0.28							no		0.50	0.26	0.30			0.28					0.58	1.07			0.47		0.30			n/d	0.22	0.81			n/d				
25	no	T			2.78	0.20	0.70					no		T		0.20	T		0.76	0.09			0.19		0.12	0.04		0.09					n/d	0.36				n/d		0.12		n/d
26	no	0.80		0.20	0.20	1.14	T			0.21		no				0.50	0.70		0.62			0.14							T				0.05	T		n/d		0.79		0.22		n/d
27	no			T					0.77	0.22		no		0.20		T			0.53	0.35		T							0.15			T	0.10		n/d	n/d		0.06		0.92	n/d	n/d
28	no		0.40	T			T	T				no		2.30					0.15								0.29	2.32		n/d	T	T			n/d	n/d	T				n/d	0.74
29	no		0.55	0.80	0.23		0.10	0.49				no	0.32	1.21						T		0.27			0.17		0.04			1.28	0.39				n/d	3.87			n/d		0.13	0.63
30	no				0.70	0.67	0.40	0.22	0.20			no	T	T				0.40	0.04	0.12	0.07	1.80			0.19					0.99					0.29	0.03	0.21	n/d	n/d		T	T
31	no		1.51		0.15	0.51		0.16	0.38			no		0.10			2.10	0.15	0.42	T				T	0.18	0.50	0.07		0.51		0.03				T			n/d	n/d		0.10	
Total		6.61	7.98	3.64	7.23	6.64	4.38	2.00	2.80	3.15			5.47	7.14	1.81	2.33	7.41	4.45	5.45	4.67	5.63	5.55	1.14	7.36	3.76	3.78	3.52	4.77	4.80	5.40	4.25	1.41	3.89	6.90	8.09	8.60	2.50	3.69	2.03	3.80	5.23	5.47

No climatic data were being collected during the years from 1958 through 1965.

T - Trace (less than 0.005 inches) | no - no climatic data were collected in May 1948 and 1966 | n/d - no rainfall data for this day | Rainfall data are in inches.

DAILY RAINFALL FOR JUNE 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57		66	67	68	69	70	71	72	73	74	75	76	77	78
1	no		0.10		0.57	0.66	T		0.22												0.50		0.08	
2	no			T					1.30	0.99		T		T			T			0.80	0.53	0.32	0.30	
3	no		T	0.27					0.10	0.10					1.73	0.50	0.52		0.14	0.27			0.05	
4	no		0.58	0.90	0.20		0.10							T		0.15	1.19	1.14						
5	no	T	T	0.40			T			0.94						T		0.60	0.42		0.66			T
6	no					1.14										0.96	0.12		0.02		1.23		0.11	
7	no					0.21		T				T					0.11				0.18		0.06	T
8	no			0.33				2.23		0.75							0.10			0.06				0.76
9	no				T	T		0.50	T			T			0.20		T						0.77	
10	no		0.16	1.65	0.41		T		T			0.36											0.09	
11	no	T	0.30					0.88		T														
12	no			T		0.50		0.13		T				0.50		0.11				0.06	1.29			
13	no			1.40		T	T					T		0.60					0.48		0.57		1.00	0.09
14	no		0.81		T										T		0.50					T		
15	no	T	T		0.40							0.10			0.96	T	0.10	T					0.23	
16	no	0.30	T				0.30		T	0.65		T		0.35		0.34	T	0.17	0.35	0.25	0.70			
17	no	0.22			T				0.41	0.15		T		0.35		0.32		0.18	0.12		0.18	0.35		0.05
18	no	0.11	T						0.80						0.18	1.00		T	0.04				0.43	
19	no	T	0.28		T			1.13				0.11	1.43		1.20	1.71		T						0.02
20	no		0.65					T	0.90					0.80				0.47			0.26		T	
21	no	T	0.10		0.70				0.21							1.30	T	1.11	T	0.20		0.09	0.02	T
22	no	T		0.38	0.26	0.10							1.30			0.20		0.70	1.74			0.06		0.24
23	no			0.23	0.77		0.20	1.14	0.36				0.90					0.60						
24	no		0.10					0.30	0.70	T			0.44							0.65				
25	no	T						0.31		0.91					T			0.36		T		0.02		
26	no	T		T			T			0.60						T				T	T			T
27	no	T		0.21					0.14			T		0.39		0.74		T	T		T			0.34
28	no	T		0.18		0.35			T	0.30				T				0.35		0.74	2.26		0.57	0.24
29	no		0.17	0.15	0.20					0.13		0.20				T		0.74	1.44		0.40		3.60	
30	no	T		0.19	0.40			0.20		0.40			2.10									0.40		
Total		0.63	3.25	6.29	3.91	2.96	0.60	6.82	5.14	5.92		0.77	6.17	2.99	4.27	7.33	2.64	6.42	4.75	3.03	8.76	1.24	7.31	1.74

DAY	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1	0.92		0.02	1.24	T								n/d	n/d	1.04			
2		0.04	0.36	0.49	0.19	n/d		T	T			n/d	n/d					
3		T	0.03			n/d						n/d	T		0.11		n/d	T
4	1.42	1.17	0.04	0.11			0.31		0.05			0.74			0.10		n/d	T
5			0.08				1.57		1.02					1.51	n/d		0.47	0.13
6	0.09				0.48	0.25					0.92				n/d		0.02	
7				0.79	0.13						0.86	T			0.09	T	T	
8							n/d			0.18				T	0.02	T		
9		2.04	0.06				n/d		0.10	0.17	0.54	n/d			0.14			
10		0.27	0.28	T		n/d	0.18		0.21		n/d	n/d						0.18
11	0.24		0.03	0.08							n/d	0.58				n/d		
12							T	1.32	0.02		0.36		0.02			n/d		0.11
13								0.61			0.04					0.06		0.51
14				2.37		1.10					1.00							
15			1.72				n/d		T		0.24	1.16			T			
16		2.27				n/d	n/d		0.21		0.12						1.37	
17	n/d		1.00	0.27		n/d	1.79	0.60		0.05	n/d		0.04				n/d	0.12
18	0.24					0.15	0.07				n/d		0.75				n/d	0.98
19						0.48					0.21	1.49	T	0.47	n/d		0.41	1.68
20					0.45		0.07	T		T	0.26	0.22			n/d	0.05	0.41	0.10
21					3.26			T	T		0.25	0.17			0.30		T	0.12
22	0.02		1.70		T				0.64		1.09		n/d	T	1.20	0.18		
23				T		n/d		T	0.15		0.79	n/d	n/d				T	
24						n/d	1.00	0.05	T		n/d	n/d	0.06	0.08		0.01	n/d	
25	0.07					1.07					n/d	1.29		0.45		n/d	n/d	0.44
26			0.45			0.08			T		0.10			0.10	n/d	n/d	0.09	
27									n/d						n/d	0.12	n/d	
28				0.33			T		n/d		0.04				0.13		1.22	
29	0.22			0.52	1.30		T		0.13		T				0.05	0.12		
30	0.60	1.07		T		n/d			T			T			T	0.22	0.49	
Total	3.82	6.86	5.77	6.20	5.81	3.13	4.99	2.58	2.53	0.40	6.82	5.65	0.87	2.61	3.18	0.76	4.48	4.37

No climatic data were being collected during the years from 1958 through 1965.

T - Trace (less than 0.005 inches) | no - no climatic data were collected in June 1948 | n/d - no rainfall data for this day | Rainfall data are in inches.

DAILY RAINFALL FOR JULY 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57	66	67	68	69	70	71	72	73	74
1	no	0.13		T			0.42	T								0.20	T		0.27
2	no	0.10				0.13			0.51				0.44		0.73	0.17	1.12	0.03	
3	no		T			T			0.53			0.97	0.54					0.04	
4	no			1.98	0.70		T		0.25		T						0.90	0.92	
5	no		0.27	0.10			0.36		0.19	T	0.20	T		T					0.97
6	no	0.15	0.40			T		T	0.30				T						
7	no	0.25			T		0.20		T	0.20		T		0.13			0.69		
8	no				1.92	T	T		0.25	0.60		T		T					
9	no		T		0.89				0.73	0.62		0.16			0.30				
10	no	0.22	0.39		T			0.81						0.11	1.82	T			
11	no		0.30									0.20		0.20		1.00	T	1.11	0.02
12	no	1.86	T	0.13										0.17		0.70	0.44		
13	no	0.60	0.40				T		T										
14	no	T					0.16		T	T		T							
15	no		0.63	T	T		0.42				0.30	1.93			T		0.40	0.41	
16	no		0.16	T	0.48				T			0.15			T	T	0.12		0.43
17	no	0.10	T	0.47															
18	no		0.20	T	T		T												
19	no			0.70	T	0.80			T				2.15	0.43		0.50			0.42
20	no		T		T	0.46	0.80		1.14				0.12	T	0.26				
21	no	0.30							0.90					0.35	0.27			0.32	
22	no	T		T	T	0.35			0.30			T		0.50					
23	no				T	1.35			0.40	0.42				0.52	T				
24	no		0.10	T				0.26	0.15	0.50				T	0.36				1.33
25	no											0.29			0.14	0.30			
26	no		0.30									T				T	T	0.14	
27	no	T			T				0.30							T			
28	no		0.20	0.91	0.30			0.10	0.40	0.10	0.70	T		2.82					
29	no				0.10			T	T	T	0.60			0.70	3.30	0.50			0.11
30	no	0.93	0.20					T				1.32		0.50	0.15	1.69	0.70		0.49
31	no						T	T				T			1.80		0.60		
Total		4.64	3.55	4.29	4.39	3.09	2.36	1.17	6.35	2.44	1.80	5.02	3.25	6.43	9.13	5.06	4.97	2.97	4.04

DAY	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1											T		0.81					0.63	T	0.01	n/d	0.77
2				0.80	1.26		0.78					0.49	0.40				0.33	1.00	0.35	n/d	n/d	
3				3.14		0.32		n/d		0.54	0.02		n/d				0.02	n/d	n/d	n/d	0.01	0.81
4	0.05							n/d					n/d		n/d		n/d	n/d	n/d	n/d	0.87	
5				0.04	0.57			n/d	T				n/d		1.26		0.04	n/d	n/d	2.63		
6							2.54	0.33	T	0.78	n/d		0.03		0.54	0.16	n/d	0.45	0.68			
7		0.03	0.83								n/d		0.02		0.50		n/d	T	0.12	0.18		
8		0.82				0.16				n/d	1.06		0.30				0.88					T
9	T	0.37						1.00		0.25	0.17	T		n/d				T		n/d	0.39	0.34
10	3.55	0.07								T	0.68		T	n/d		0.32				n/d		0.02
11	0.32	0.69	0.03								1.00	T	n/d	0.03		0.58				0.10	0.01	
12		0.55	T							0.24	1.00	n/d	n/d	0.83		T						0.12
13		T	0.10		0.67						n/d	n/d	1.06	T	0.56	1.87	n/d	T				n/d
14	5.80										n/d	0.03	0.25		0.03	n/d	n/d		0.10		0.16	n/d
15	T	0.04									0.43		0.02		n/d	n/d	0.44		0.72	1.18		2.86
16	0.16	0.32			0.32						0.47	T		n/d	n/d	1.20		0.39		n/d		0.19
17				T	0.02	0.02				0.36		0.13		n/d	1.10			T		n/d		
18			0.24							0.26				0.27						1.68	0.03	0.06
19										0.16		n/d		T					T	0.51		0.58
20			0.12				0.16	0.67			n/d	n/d			1.64			T	2.19		0.34	n/d
21	0.54				0.10		0.15	0.03		n/d	n/d	0.83		0.59	0.20	n/d					0.04	n/d
22		0.16				0.28			T	n/d	0.35			1.01		n/d	T	T		0.21		0.18
23		0.14				1.17		0.29		2.10	0.02			n/d		0.19		0.82		n/d		0.04
24					0.28	0.25								n/d				0.31		n/d		
25	0.21	0.23	T	0.39							0.12		n/d	1.45			0.21	n/d		1.99		
26			0.81		0.12						0.68		n/d		1.21		0.79	n/d	T	0.05		0.65
27							0.07			0.33	n/d		0.06	0.91	T		n/d	0.26	T	0.41		n/d
28				T			0.21	0.31		n/d	n/d			0.47	0.14		n/d	T		1.13		n/d
29		0.09				0.08	0.37			n/d	0.55	T			n/d		0.27		0.16	0.01		0.14
30		1.28			0.58			0.02		0.04		T		n/d	n/d		1.00				n/d	1.69
31				0.73				n/d			0.03			n/d	0.32			0.77		n/d	1.64	0.35
Total	10.63	4.79	2.13	5.10	3.92	2.28	4.28	2.65	0.00	5.06	6.58	1.48	2.95	5.56	7.50	4.32	3.98	4.63	4.32	10.09	3.49	8.80

No climatic data were being collected during the years from 1958 through 1965.

T - Trace (less than 0.005 inches) | no -no climatic data were collected in July 1948 | n/d - no rainfall data for this day | Rainfall data are in inches.

DAILY RAINFALL FOR AUGUST 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57
1	n/d		0.19							
2	n/d	0.21	1.22		0.14	T	T			
3	n/d	0.80	1.29				0.89			
4	n/d	0.40			T	T		0.30	T	0.43
5	T	1.30			0.30	T	0.25	T	2.60	
6			T	T	0.83	T		0.95	0.10	
7				0.56	0.30			0.60		
8				T	0.70	0.85	0.10	0.23		
9	0.32				0.70	0.10	0.60			T
10			T		0.14			0.10	T	0.24
11	0.36		0.49	T				0.29		
12	0.20	0.20		0.60	0.20			4.59	0.47	0.24
13		0.15			0.10			1.71	0.52	
14						T	T	0.19	0.20	
15						T	0.70			
16			T	T	T	T	0.47	T		
17		0.60				0.67		0.37		
18	1.01	0.48	T					2.57		
19	0.29		0.80	T			0.40	T		0.17
20	0.16		T	T			0.47		0.76	0.80
21				0.46	0.41		1.43		0.58	T
22	0.04		0.10					0.60		
23		T						0.68		
24		0.10								
25										1.17
26							0.30			0.53
27								0.10		
28		0.70			0.60		T			
29		0.11	T		T			0.20		
30	T		0.29				T	0.40		T
31	T	T	0.64		0.90		0.21	0.88		
Total	2.38	5.05	5.02	1.62	5.32	1.62	5.82	14.76	5.23	3.58

DAY	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
1		0.56	T	T				0.02					0.33		0.03	
2	T		1.30			4.80	T	1.05				0.65	0.06	0.08		
3		T		0.23			0.90	3.55				0.52				0.03
4	0.20	4.15		2.35	0.49	0.61			0.20				T		0.71	T
5	0.27	0.80		0.15		1.40			0.39	0.22			1.73			
6			T				0.20			0.04				0.46	0.04	T
7			1.40				0.38		0.26		0.66		T			
8		0.15									1.10		0.17	T		
9	0.20	T	0.60	T					T		0.12	0.35		T		
10	0.75	1.44		1.20							0.36	1.25	0.46			1.51
11	0.20		0.17			1.57						0.55			0.22	0.22
12	0.12					0.60	0.42						0.20		0.19	0.39
13									0.05			n/d		1.37		
14		T	0.90		0.12		T	0.22	T	1.63	0.51	n/d				
15	0.40							0.04	0.63		0.54			0.03	0.07	
16	T		T		0.50		0.60									0.43
17	0.18		0.40		T		0.40		1.00	0.36		0.75				
18				0.19											0.11	
19		T		0.10	0.47	T									1.45	
20		1.25		T	T			0.17		0.45				0.10		
21		T			0.84			0.04						0.06		
22	T	0.39						0.16		T		0.53			T	
23	T	T	0.26		1.17				0.62	0.41				0.10		
24		0.60	1.80						2.30			0.32		0.20		
25		0.88	0.25									0.20				
26		0.20	0.15													
27		1.85				5.17	0.38		0.12	0.21	1.49			2.11		
28		1.35				0.82			T		0.03		6.19	0.54		
29									0.12					0.11		
30												0.37	T	0.17		
31					0.15					0.40			0.34			0.23
Total	2.32	13.62	7.23	4.22	3.74	14.97	3.28	5.25	5.69	3.72	4.81	5.49	9.48	5.33	2.82	2.81

DAY	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1	n/d	T		0.03			0.09	T			n/d		n/d		0.44
2	0.11	T	T		n/d						n/d				
3			T		0.92						0.76	T		T	T
4			n/d						n/d		T				
5			n/d			T			n/d	T		0.02	0.43		
6			0.38			0.17			2.04			0.85			
7		n/d	T	0.87	T			T	0.54			n/d			
8		2.33	0.06	0.63	T					T		n/d		0.01	
9	1.00								0.89	1.78		0.19			0.16
10	0.08		0.03	n/d			0.07		0.50	n/d	T				
11	T		n/d	n/d			T		n/d	n/d	0.21				
12	0.49	0.99	n/d	0.13				n/d	0.31	0.09	0.19	0.17	0.91		T
13			0.85					n/d			T	0.07			2.89
14								0.32	0.15		0.41		n/d		
15										0.21	n/d		0.56		
16					n/d		0.17				n/d	T			
17				n/d	n/d					n/d	0.98	T	0.76		
18	0.82	0.02	n/d	n/d	0.06			0.04	n/d	n/d	0.20	0.22	0.19		
19			n/d	0.18		0.02	0.21	n/d	n/d	0.16			T		
20			0.03	T	0.03		0.57	n/d	0.31	2.88	1.00				
21				0.34	1.55			0.52	0.02	T		n/d			T
22			0.13		0.35	n/d			1.20			n/d	0.94		
23	0.27	1.02				n/d			0.40			0.06			
24	0.52			n/d		0.36	1.18		T						
25	0.04			n/d			1.64		n/d	n/d					
26				1.79					n/d	0.11			0.25		
27	T					1.00	n/d		0.42						0.32
28					0.50	0.05	n/d					n/d			0.01
29		T					1.67	T			n/d	0.01	0.28		
30		T		0.02			T	0.46	0.81		n/d				
31	T	T				T				n/d	0.24				
Total	3.33	4.36	1.48	3.99	3.41	1.60	5.60	1.34	7.59	5.23	3.99	1.59	4.32	0.01	3.82

No climatic data were being collected during the years from 1958 through 1965.

T - Trace (less than 0.005 inches)

n/d - no rainfall data for this day

Rainfall data are in inches.

DAILY RAINFALL FOR SEPTEMBER 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57	66	67	68	69	70	71	72	73	74	75
1			T		1.99				T											0.43
2				T	0.65			0.10					T	0.30			0.62		1.05	
3			T	T	0.11		T	0.10		T				6.38				0.02	0.24	
4														3.30					0.97	
5						0.96														
6				0.45		0.10			1.30				0.42						0.13	0.39
7	0.03	0.10			0.12	T	T		0.10	0.64				T					0.93	
8	0.02	T					0.30							0.26					0.67	
9	0.07		0.98				T			0.30				0.17	0.59					
10	1.03		0.47				0.30			3.33		T	0.51		0.15					
11			2.90	T			0.90	T					1.50		0.10	2.00	0.11		0.04	
12		T	T			0.16			T	0.20	T					1.10	T			0.02
13		0.43	0.66							0.29	0.30						T		0.04	0.59
14		0.70	T	0.21	T	T				T	2.20							1.99	0.85	
15				0.30	0.30		T		0.13		0.40							0.79		
16		0.90					0.35		T	0.66		T								T
17									0.16	0.88						0.78	0.60		T	
18	T	0.48			T		0.31					0.15		0.26	T			0.08		0.04
19		0.40	T		0.10		0.56	0.70	T											1.34
20						0.21	0.60	0.50	0.30	T	1.80						T			
21	0.05		1.10			0.34	0.28				0.78	T				T	0.10			
22		1.28	0.30	T	0.13			0.10	T		0.26	T							0.42	T
23		0.40	T	0.12	0.50			0.30	0.25	0.17						0.20		0.02		1.91
24								0.48	0.28			T								1.53
25				T							0.30			T						3.37
26											T					0.30	T			0.32
27		0.32							0.85		0.34				0.34	0.11	0.19			
28		0.40						0.14	0.25		0.13	0.12		0.90			T			
29		0.24	T								0.61	0.24					0.30		1.62	
30	1.62		T	T				0.14	T	0.30								1.06		
Total	2.82	5.65	6.41	1.08	3.90	1.77	3.60	2.56	3.62	6.77	7.12	0.51	2.43	11.57	1.18	4.49	1.92	3.96	6.96	9.94

DAY	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1			2.17			T	T					0.22			n/d				0.01		
2	0.29				0.07	0.03	T				0.44				n/d					n/d	
3	0.14						0.39						n/d		n/d		0.23			n/d	
4									0.41				n/d		0.09		0.66	n/d		0.32	T
5				0.16	0.05						0.04	n/d	n/d			0.62	n/d	n/d			T
6				3.62								n/d	2.09		0.15	0.03	n/d	n/d		T	0.12
7		0.22										n/d			T		n/d	0.05		0.19	
8						0.47	0.06		n/d		T	1.56					0.59	0.05			
9		0.02				0.06			n/d	0.12		2.10					T			n/d	0.39
10	0.37								0.04	T								1.05		n/d	
11										0.06							0.78			1.91	0.59
12											T	n/d									0.01
13		T	1.32					1.19				n/d	0.34		0.03						0.44
14		T		0.06				0.07				2.91			T	n/d					
15	T	T	T			0.09			0.02						n/d	n/d				0.29	
16	1.89	T				2.67	T					0.11		n/d	n/d	0.51		0.26		0.75	0.24
17	0.24	0.33		0.24		0.02			1.01			1.00	n/d	n/d	0.62			1.41	n/d	n/d	1.93
18					0.91	1.12						1.03	n/d	1.90		1.18		n/d	n/d	0.32	0.09
19				0.02							0.12	0.02	0.04	1.26	0.18	0.24		n/d	0.10	0.42	
20		0.09					0.57	T				n/d		0.60	0.06	0.38		0.33		0.02	
21	0.04			0.22			1.00	0.06				0.05	T	T		n/d		0.20			n/d
22		T	T				0.49	0.77				0.04		0.40	n/d	n/d	T		0.25		n/d
23		0.06				0.46	0.02			0.17	0.07			n/d	n/d	1.00	0.58	0.03	0.76		1.22
24				1.92									n/d	n/d	1.24						T
25				T	0.44				0.04		T		n/d	0.05		1.19	0.37	n/d			0.03
26		0.07			0.03				T	T	0.02		0.70	0.85	T	0.58	n/d	n/d	0.26		
27	0.19	T					0.71			6.00	0.39						n/d	2.42	0.87		0.02
28	0.07	0.14		0.06		0.02			0.16								2.00	0.08		0.69	n/d
29				0.15					n/d						n/d		T		0.21	0.47	n/d
30	0.67								n/d			0.14			n/d			0.01			0.88
Total	3.90	0.93	3.49	6.45	1.50	4.94	3.24	2.09	1.68	6.35	1.08	9.18	3.17	5.06	2.37	5.73	5.21	5.89	2.46	5.38	5.96

No climatic data were being collected during the years from 1958 through 1965.

T - Trace (less than 0.005 inches)

n/d - no rainfall data for this day

Rainfall data are in inches.

DAILY RAINFALL FOR OCTOBER 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57	66	67	68	69	70	71	72	73	74
1							T				0.95					T			
2					0.58		T		T		0.10			0.18		1.00		0.41	
3							T						T	0.29				0.25	
4			T				T		0.35						0.40		0.11		
5	0.86	T					T	0.14			0.25	T					0.40		
6	T	T				0.25	0.10	0.25	0.13	0.53		T					0.73		
7	T	1.72	T	0.52				T	T	0.37			1.60						
8	0.08		0.40					0.49		0.41		T		0.56					
9			0.65		0.60							T							
10			0.40	0.70	T						T	0.66				2.85			
11	0.02			0.41	0.32						T						T		
12			0.15			T													
13	0.15							0.56						T					
14	0.04	T	T				T	0.30				T		T	T				
15		T					0.92	0.20							0.60				
16								0.76			0.16				0.40			T	2.13
17	T								0.10	T									
18	0.43	0.10						T	0.36	0.62	T	0.70	0.30				1.52		
19		T					0.40	T			2.00	T	0.60						
20					T		0.12				T								
21									T					0.33	0.70		0.20		
22		T	0.37						0.70						1.60				
23	0.05		1.48						1.70	T				T	0.52		0.80		
24	T			0.78		0.21		0.90	T	0.61			0.40						
25	T	0.41									0.10	0.62	0.30			0.93			
26		1.12					0.70		0.30	T		0.22			0.17	2.00			0.02
27						T	0.13		T	0.20							2.10		
28		0.22	T	0.24	T	0.82					T			0.20					
29		0.10	T		T	1.72	0.92	0.20					0.30					1.66	
30	T	0.16		T			0.31	0.80	0.10	T			T		0.23			0.35	
31		0.63		0.23					0.51						T	0.20	0.19		
Total	1.63	4.46	3.45	2.88	1.50	3.00	3.60	4.60	4.25	2.74	3.56	2.20	3.50	1.56	4.62	6.98	6.05	2.67	2.15

DAY	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1		0.97	0.12		1.14		0.02		n/d	1.50				n/d	n/d	n/d				n/d		
2	T	0.45		T	0.02		0.63		n/d	0.27	0.03	1.12		n/d	1.40				n/d	n/d		0.26
3		0.52			0.34	0.51			0.29		0.74	T	n/d	0.38	T		1.00		n/d	0.21		0.01
4				0.17							0.46		n/d	0.07		0.47			0.03			
5				0.03	0.56	0.60			T		n/d		0.27			0.04	n/d					
6		T	0.09	0.07			0.09			n/d	n/d				1.00	n/d	n/d					
7						0.02	0.04			n/d	0.06		0.35		n/d	n/d	0.43				n/d	
8		0.08								n/d					n/d	n/d					n/d	1.63
9	0.25	1.70	1.45		0.49					0.02					n/d	0.08		0.87	n/d	n/d	2.12	0.21
10	0.07				1.69	0.16							n/d		0.06			n/d	n/d	n/d		
11									T			n/d	n/d		0.09	T	0.12	n/d	n/d	0.10		
12	0.28				0.20			1.00	0.67			n/d	n/d			0.23	n/d	n/d	1.14			
13								0.39	0.03			n/d	0.04			n/d	n/d	0.79			0.06	
14			0.47			0.07		0.09	1.04			1.15				n/d	n/d				1.85	
15			n/d		0.08						T	0.02				0.08	0.06		0.01			
16			n/d	T						T	0.05						0.02		n/d			
17	0.22	0.23	0.75	0.59								T			0.71		1.13	n/d	n/d			
18	0.45													0.04	0.07	0.18	0.14	n/d	0.02			1.26
19	0.65		0.02	0.02		0.31	0.53		0.36					T	1.12	0.66		1.00		T		1.29
20	0.45	1.04							T						0.74	n/d			0.40	T		0.53
21		1.05								n/d	0.42		0.09	0.27		n/d			0.01		n/d	
22									n/d	0.03	0.29			n/d					0.03	n/d	n/d	
23							0.25		n/d	0.67	0.03			n/d		0.99				n/d	1.37	
24	T	0.40			0.87				2.10	0.65	1.02			1.90		0.10		n/d		0.49	0.04	
25	0.08	0.87						0.97	0.08		0.07							n/d			0.22	
26			0.32				1.21	0.42	0.03			n/d					n/d	0.25		T	0.15	
27			0.52	0.06		1.84	0.04			n/d		0.48	0.18			n/d	n/d		0.05		0.01	
28			0.02		0.13	0.08	0.73			n/d		0.28	0.95	T		n/d	0.02		0.11		0.03	0.16
29							T			0.53												
30	0.04																		n/d			
31		1.27													0.61			n/d	n/d		0.37	
Total	2.49	8.58	3.76	0.94	5.52	3.59	3.54	2.87	4.60	3.67	3.17	3.05	1.88	2.66	5.80	2.83	2.92	2.91	1.80	0.80	6.22	5.35

No climatic data were being collected during the years from 1958 through 1965.

T - Trace (less than 0.005 inches)

n/d - no rainfall data for this day

Rainfall data are in inches.

DAILY RAINFALL FOR NOVEMBER 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57		66	67	68	69	70	71	72	73	74	75
1	0.03	0.13		1.70					1.77	0.29								0.60	0.22		
2	T			0.91			0.75		5.79	0.40		0.27	1.40		0.17	T	T				
3	0.30			0.98	0.20		T	0.20	0.10			0.17	0.14		T	0.98	0.65				
4	0.03		0.34				0.30						0.50	0.60		0.90					
5	0.02						0.16			0.19					T	1.60			0.19	0.13	
6	0.49	0.30		T		0.56				T		0.50			0.26					0.40	
7	0.29	T		1.36		0.45		0.12						0.30	0.40		0.21	1.66		T	
8									0.70	0.50				0.30	0.32						
9					T							0.20							0.07		
10	0.22				0.32			0.57				0.17		1.21		0.11		0.90			0.59
11	T		0.10					0.80				0.20		T							0.23
12	T	T							T			T	T	0.70	0.15	0.98				0.26	0.54
13	0.16	0.26		0.20								T				0.17		1.83		0.16	1.42
14				0.14						0.59					0.15			0.19			0.12
15					0.35			T					T		T	1.19	0.20			0.14	
16			T	0.33			T	0.10	T												
17	0.09				T		T		0.65				T	T							
18							T		0.18	0.27		0.20	0.11								
19	0.15	0.10			T		0.12	0.11		0.28				0.75	0.19		T	1.67	T		
20	0.03		0.46		1.36		0.52								0.49	0.50				0.09	
21		T	0.20		2.74	T	0.59		0.38	T			T							0.08	0.16
22	0.43				0.17	T				T			0.50							1.00	0.05
23	T		T	T		0.70		0.10	T	0.27			0.11								
24	0.05	0.90	0.10	0.50		T	0.20						0.10				0.10		0.05		
25	0.61	0.30	2.42	0.23		0.27	T	T	0.27				T	0.21			1.91	0.69	0.07	0.06	
26	T	T	T	0.33				T	T	T		0.22		T						0.06	
27	0.44				T	T	0.20											T	0.04		0.02
28	0.94	0.12	T				0.68			0.20		1.30		0.60					0.10		
29	0.55	0.31			0.11		0.20					0.30					S	0.96			
30					0.25					0.42		T	0.45				1.20	0.50			
Total	4.83	2.42	3.62	6.68	5.50	1.98	3.72	2.00	9.84	3.41		3.53	3.31	4.67	2.13	6.43	4.27	9.00	0.74	2.38	3.13

DAY	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1													0.47	0.02			n/d	n/d	0.33	0.12	0.21
2		0.17		T					T				T				n/d				
3		0.27		1.33				0.09	n/d					0.15			1.33	T		n/d	
4	0.16	0.14			0.49		T		n/d	0.06	0.71		T	n/d			T	T		n/d	
5							1.17		0.93	0.26	0.58		n/d	n/d			0.18	0.37		n/d	
6		0.27				0.52				0.20	0.77		n/d	0.02	0.13		0.17	T	n/d	1.29	
7		1.25									T		0.12						0.03	0.97	
8	T	0.22									n/d			0.30		T				0.62	1.71
9				0.02							n/d			0.33		n/d					0.10
10		T			0.03	1.00		1.02			0.72	0.60			n/d	n/d			0.42		0.01
11		0.47						n/d		0.02		n/d	n/d		n/d	n/d	n/d			n/d	
12	T						n/d	n/d			0.69	0.42	n/d		n/d	0.20	0.04			n/d	
13			0.02	1.17			n/d	n/d		T			0.38		1.46	0.16	0.98	n/d		0.03	
14				0.08			n/d	0.35		T								n/d			
15			0.02		T	0.12	1.35	0.39						0.07				0.10			
16			0.21	1.00				0.16		n/d			0.05	0.33					0.52	n/d	
17		0.22	0.34			0.03			n/d	n/d			1.06		n/d			T	T	0.32	
18		0.07	0.92		1.06				n/d	0.64		T			n/d			0.28	0.03		0.02
19									0.67		0.72		n/d		0.11		0.12	T	n/d		
20						0.13		n/d			0.60	T	n/d				T		n/d		
21		0.03						1.37			0.98		1.09	T		T	n/d		0.55		
22	T	0.07					0.03			0.97					n/d	1.10	n/d		0.01	0.64	
23		0.78	0.14								n/d			0.29	0.09	n/d	0.95				
24			0.12		0.93	1.00	0.02	n/d		n/d	0.28			T		n/d					
25		0.31			0.12	T		1.29		0.02						0.22	0.11	T			0.07
26				0.67						0.04	0.66	n/d	n/d				0.30		n/d		1.19
27			0.54	T						0.02	n/d	0.02	n/d				0.11	n/d	n/d		
28		0.12	T		0.32		n/d	0.34		n/d	T	n/d	1.97	T	1.00			n/d	1.08		
29	0.49	0.23					1.47		1.55	1.20		n/d			T			1.68		0.03	
30		0.09	0.62									1.90				n/d					0.11
Total	0.65	4.71	2.93	4.27	2.95	2.80	4.04	5.01	3.15	3.43	6.71	2.94	5.14	1.51	2.79	1.68	4.29	2.43	2.97	4.02	3.42

No climatic data were being collected during the years from 1958 through 1965.

T - Trace (less than 0.005 inches)

n/d - no rainfall data for this day

Rainfall data are in inches.

DAILY RAINFALL FOR DECEMBER 1948 THROUGH 1996

YEAR (1900's)

DAY	48	49	50	51	52	53	54	55	56	57		66	67	68	69	70	71	72	73
1							T			no					T				
2		0.70			0.45		0.10	0.40		no				0.35					
3	0.55		T		0.20		0.10			no			1.83		T	0.20		T	
4	0.67	0.20	1.32	0.68	T	T	T	0.10		no				0.96		0.20			
5				1.44	0.52	T			T	no				T				0.60	1.49
6	0.01				T	0.98	T		T	no		T					T		0.16
7		0.13	0.60			0.21				no			0.90		0.31		0.87	1.10	
8				0.50					0.30	no		0.10			0.83		T	S	0.25
9				T		0.50	0.64	0.16	0.16	no				T		T		0.95	0.95
10		0.10	0.29		0.25	0.20				no			0.30		0.38		T		
11		0.21	0.20		0.79		T		0.20	no		0.33	0.95		1.21	T		0.90	T
12	T	0.29				0.54	0.40		0.17	no			0.75			0.37			
13	0.01	0.45			T	0.21	0.40		0.39	no		0.36							0.17
14				0.48	T	1.15	0.33		1.70	no		0.35	T	0.76	0.25		T	1.15	0.40
15	1.37	T	0.90	0.53			0.70	T	0.66	no					T		T		
16	0.57					T			0.22	no						0.18			0.03
17	0.05								T	no					T	1.31			0.45
18		0.34		0.25			0.47			no			T						
19	0.71	0.70						T		no				0.10				0.50	
20				1.16	0.10				n/d	no		0.40					T	0.90	
21				0.50	0.79	0.10			0.40	no		0.20		T		0.17		1.12	2.50
22			T		0.40	T			0.32	no			0.45		1.58	0.77			
23		0.16						T	0.33	no			0.30			0.14			
24									0.23	no		1.20			T	0.15			
25	T			0.23						no		1.40						0.38	
26		0.72	T						0.60	no			0.12		2.34			0.60	0.34
27		0.12							0.30	no				T					0.41
28			T			T	0.15			no		0.38	0.49				T		
29	0.39		0.28	T			0.87	T	T	no		1.10	0.59					T	
30	1.25		0.20	0.30			0.23			no					0.50		T	0.21	
31	0.02		T	0.30	0.78					no			0.70	T	1.33				
Total	5.60	4.12	3.79	6.37	4.28	3.89	4.39	0.66	5.98			5.82	7.38	2.17	8.73	3.49	0.87	8.41	7.30

DAY	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
1	0.90	0.06		0.89				0.39	0.37		n/d	n/d				T		n/d	T				1.15
2	1.18							0.61	0.04		n/d	0.52	1.02				n/d	n/d	T			n/d	0.36
3	T								0.02	n/d	0.31		0.76				0.47	1.31	T			n/d	
4		T			0.97			1.00		n/d				0.10			1.05	0.18		n/d		0.27	
5				0.32	0.64					1.25							T			n/d	1.07		0.36
6				0.06		T			0.02	0.35	0.93	T				1.00				3.31		T	0.69
7		T	1.52	T		0.19		0.21		0.26									T			0.17	0.59
8	1.63	0.04			0.12			0.26		T			0.05			0.26							0.01
9		0.09		0.05	n/d		0.11						0.41	0.02	0.02	n/d		0.02				n/d	
10		0.07			n/d		0.02						0.14			n/d		1.06	0.34	T	n/d	n/d	
11									n/d	n/d			0.36	0.21		0.05			2.07	n/d	n/d	0.75	0.25
12	T		T				T		0.14	2.10		T	0.14			0.11			n/d	n/d	0.75	n/d	0.28
13						0.52			0.14	2.05	T	0.63			T	0.15		0.09	n/d	0.03		1.17	2.35
14				0.82				0.24		0.02	T					T			0.15		T	T	0.32
15		T		0.30			T	1.09			n/d			0.71			n/d			0.01			
16	1.49		T				0.12	0.52	0.82		n/d			0.03		n/d	n/d	T	T	0.18			
17						T		T			0.03					n/d	0.76		0.65		n/d		0.06
18				3.00									0.96			1.00	0.29		T	n/d	n/d		0.05
19	0.02			0.30		T			0.03		0.07			n/d	T	T	T		n/d	n/d	0.01		0.28
20			0.19	0.04	T	T			0.02			0.02		n/d					n/d	0.03			
21			0.15	0.51	0.37						T	n/d		0.22	0.34		0.43		0.15	0.79			
22	0.03	T						0.02		1.36	n/d	n/d			T		n/d	n/d					
23		T					0.13	1.00			n/d	0.03		0.03	0.24		n/d	0.11	0.09				
24	T						0.20				n/d		0.26		n/d		0.85	T	T		n/d		0.40
25					1.66	0.74					n/d		2.43	n/d	n/d				n/d		n/d		
26		n/d	0.15						0.02		0.45			n/d	n/d	T			n/d		n/d		
27		n/d	0.05						0.02		T			n/d	0.04		T		n/d	T	0.01		0.01
28								0.03	1.00	1.02				0.59	0.27		1.16	n/d	0.39	0.09			
29			T						0.06					0.27	T		n/d	n/d	0.03	0.02			0.08
30		0.52											0.11			n/d	n/d	0.61	0.13	T			0.01
31	0.12	0.43		0.06	0.42							1.00				n/d	0.30						
Total	5.37	1.21	2.06	6.35	4.18	1.45	0.58	5.37	2.70	8.41	1.79	2.20	6.64	2.18	0.91	2.57	5.31	3.38	4.00	4.46	1.84	2.36	7.25

No climatic data were being collected during the years from 1958 through 1965.

no — no climatic data were collected in December 1957.

T - Trace (less than 0.005 inches)

n/d - no rainfall data for this day

Rainfall data are in inches.

Appendix B
Water Level Data

Appendix A contains the synopotic rounds of water level data collected from January 1995 through December 1996. The water levels are reported as elevation, based on the NAVD-88 survey system. The water level data were collected:

JAN 95	Water level data collected 9-11 January 1995
FEB 95	Water level data collected 21-23 February 1995
APR 95	Water level data collected 11-13 April 1995
JUN 95	Water level data collected 12-16 June 1995
AUG 95	Water level data collected 7-9 August 1995
OCT 95	Water level data collected 17-19 October 1995
MAR 96	Water level data collected 5-12 March 1996
JUN 96	Water level data collected 25-27 June 1996
SEP 96	Water level data collected 24-26 September 1996
DEC 96	Water level data collected 17-19 December 1996

Water Level Data for APG-AA from 1995 through 1996

WELL / PIEZOMETER	ELEVATION, FT (msl)										
	TOP OF PVC CASING	WATER LEVEL									
		JAN 95	FEB 95	APR 95	JUN 95	AUG 95	OCT 95	MAR 96	JUN 96	SEP 96	DEC 96
2-76	40.53	14.21	15.61	16.07	16.91	18.25	15.72	16.58	17.90	17.63	19.77
3-76	41.98	15.98	16.23	16.51	17.15	16.63	16.04	17.25	18.65	18.33	20.26
4-70	43.54	17.88	18.23	17.74	18.08	18.87	18.11	19.25	20.52	20.00	22.39
4-76A	40.50							18.32	19.76	19.48	21.20
4-76B	40.22							21.62	23.42	23.12	25.07
525-MW1	20.62								6.44	6.22	7.08
525-MW2	19.86							5.56	5.65	5.54	
525-MW4	19.92							5.28	5.42	5.34	
525-MW5	19.93							4.68	4.69	4.63	
525-MW7	19.83							4.49	3.45	3.48	
5-76	41.64	15.92	15.93	16.05	16.57	16.06	15.46	16.94	18.40	18.18	20.84
6-70 (HCP-6)	41.83	13.35	17.91	17.35	18.43	14.83	14.24	18.83	16.09	15.63	22.23
6-76	37.76	15.46	15.61	15.88	16.07	15.59	15.12	16.46	17.92	17.70	19.24
8-70 (HCP-5)	40.41	7.97	15.67	17.03	18.10	9.43	8.88	16.38	10.73	10.26	19.78
AA-02	57.90	32.46	32.39	32.69	32.38	32.02	31.20	32.52	34.97	35.23	36.52
AA-03	75.24	34.34	34.01	33.99	33.82	33.52	32.86	33.48	36.50	37.00	37.31
AA-04	52.20	41.13	41.61	41.68	41.35	40.38	39.35	42.66	43.47	43.52	46.92
AA-05	69.79	28.29	28.07	27.95	27.71	27.45	27.14	27.31	29.00	29.95	30.45
B-3-CB1	33.50							14.98	16.42	16.08	17.96
BTD-01	33.45	16.67	17.32		17.02	17.17	16.11	17.37	18.66	17.95	20.15
CITY-01	71.85	28.75	28.83	28.55	28.03	28.08	27.23	29.79	31.61	31.19	32.53
CITY-02	56.09	29.67	29.73	29.13	28.33	28.62	27.88	30.01	31.84	31.94	37.63
CITY-03	59.37		33.33	32.80	33.46	32.31	30.92	34.32	36.21	36.57	37.97
CITY-04	58.70	37.06	36.39	35.98	35.46	35.18	34.25	36.65	38.85	39.05	41.85
CITY-05	55.42	36.47	36.73	36.39	36.04	35.41	33.94	36.20	38.40	39.40	43.22
CITY-06	58.36	31.17	31.05	30.77	30.16	30.02	29.26	31.28	33.58	33.52	34.76
CITY-07	65.92	26.70	26.37	27.15	26.41	24.86	25.15	27.92	29.30	29.49	27.67
CITY-09	73.27	21.95	22.03	33.36	24.55	22.81	22.78	25.07	27.42	27.52	26.77
CITY-10	67.00	27.48	27.78	28.39	25.90	26.82	26.20	27.42	29.27	29.62	30.52
FF-01	17.52							13.42	14.29	13.90	14.67
FTA-M01	59.81	30.29	28.32	30.51	30.33						
FTA-M02	55.92	31.07	31.11	31.35	31.15						
FTA-M04	58.92	30.86	30.86	31.04	30.82						
FTA-M05	62.58	30.50	30.53	30.57	30.47						
FTA-M06	62.48	30.38	30.34	30.37	30.28						
FTA-M07	60.92	30.13	30.14	30.52	30.10	29.81	29.08	30.58	32.45	32.42	33.25
FTA-M08	61.39	29.89	29.88	30.07	29.87						
FTA-M09	60.77	29.67	29.69	29.84	29.68						
FTA-M10	64.55	30.30	30.24	30.40	30.19						
FTA-M11	55.34	31.16	31.25	31.45	31.24						
FTA-M12	57.12	31.36	31.49	31.75	31.56	31.05	30.29	32.34	33.57	33.54	34.92
FTA-MD-07	60.71	30.11	30.09	30.21	30.48						
FTA-MD-13	61.71	30.61	30.63	30.81	30.60						
FTA-P01	51.54	35.58	34.84	35.00	34.77	34.07	33.30	36.14	37.11	36.97	39.94
FTA-P02	43.61	33.87	33.99	34.40	33.90	33.33	32.76	34.83	35.73	36.01	37.21
FTA-P03	44.24	30.56	28.84	29.13	29.06	28.39	28.12	30.77	31.20	30.87	34.04
FTA-P04	38.99	29.89	29.76	30.94	29.70	29.03	30.08	31.69	31.89	31.95	33.27

Sheet 1 of 7

Water Level Data for APG-AA from 1995 through 1996 (Continued)											
	ELEVATION, FT										
WELL / PIEZOMETER	TOP OF PVC CASING	WATER LEVEL									
		JAN 95	FEB 95	APR 95	JUN 95	AUG 95	OCT 95	MAR 96	JUN 96	SEP 96	DEC 96
FTA-P05	53.02	31.20	31.00	31.09	30.83	30.66	30.13	30.77	32.82	33.27	33.76
FTA-P06	42.37	28.13	28.55	28.81	28.69	27.70	27.75	30.54	30.91	30.77	33.55
FTA-P07	54.02	28.64	28.74	28.92	28.81	28.35	27.59	29.63	31.22	31.14	32.67
FTA-P08	44.64		28.09				21.90	23.94	25.24	24.62	27.12
FTA-P09	42.76	26.14	12.86	26.31	26.33	25.84	25.14	27.38	28.95	28.60	30.46
FTA-P10	58.96	29.01	34.06	29.11	28.92	28.73	28.03	29.36	31.30	31.31	32.09
FTA-P11	51.61	26.73	32.98	26.84	26.80	26.44	25.71	27.36	29.39	29.19	30.29
FTA-P12	43.17	24.57	34.47	24.63	24.66	24.27	23.61	25.58	27.47	27.02	28.59
FTA-P13	32.57	23.44	16.14	24.74	25.36	24.94	23.73	24.01	25.37	25.33	25.67
FTA-P14	34.36	18.11	22.54	18.16	18.37	17.86	17.13	19.28	20.70	20.10	22.68
FTA-P15	34.26	22.41	15.39	22.52	22.75	22.15	21.52	23.60	25.28	24.75	26.51
FTA-P16	42.25	23.37	23.56	23.48	23.54	23.14	22.45	24.43	26.35	25.84	27.41
FTA-P17	44.79	26.73		26.18	26.21	25.88	25.18				
G-01	33.51							19.57	21.65	20.67	23.34
HA-88-0012	34.40	21.57	21.68	7.87	21.72	20.89	20.20	22.62	23.98	23.30	25.12
HA-88-1480	61.37	6.54	6.56	6.51	6.48	6.51	6.37	6.33	7.37	7.27	7.51
HA-88-1481	36.66					21.81	21.12	22.91	23.06	23.36	24.24
HA-88-1483	66.39	28.32	28.25	28.48	39.91	27.65	26.91	28.04	30.27	30.71	31.29
HA-88-1641	30.93	4.59	4.53	30.93	4.52	4.17	4.30	4.38	4.43	4.65	4.88
HA-88-1649	58.60	9.83	9.79	9.76	9.59	9.52	9.42				
HA-88-1650	34.81	23.10	24.19	24.25	24.40	22.84	21.79	24.46	24.53	23.86	25.71
HA-88-1670	56.89	30.23	29.97	29.85	29.58	29.36	28.97	29.39	30.99	32.15	32.89
HA-88-1697	36.41	20.45	20.54	20.47	20.26	20.52	19.83	20.84	21.73	23.31	22.15
HA-88-1780	36.22	19.57	21.20	20.51	25.11	20.11	19.55	26.34	26.89	22.52	27.36
HA-88-1844	19.00	2.47	2.58	2.70	2.92	0.59	2.68	3.45	3.79	3.68	4.61
HA-88-1893	35.22	21.48	21.73	21.93	22.20	21.74	21.22		23.68		
HA-88-2184	7.11	0.62	1.45	-0.97	0.78	1.69	1.12				
HA-88-2185	4.38	0.71	0.79	1.05	0.28	1.72	1.15				
HA-92-0661	4.86	2.24	1.94	1.62	1.58	2.24	2.45				
HA-92-0662	8.81	-0.08	1.50	0.98	0.62	2.23	1.08				
MLF-MW01	34.60	21.79	22.29	22.73	22.88	21.78	20.68	22.58	23.34	22.75	25.10
MLF-MW05	30.37	23.00	23.14	22.29	22.27	20.69	19.44				
MLF-MW06	31.99	21.48	21.86	21.58	22.64	20.49	20.36				20.93
MLF-MW07	32.26	21.88	22.36	22.67	22.68	21.24	20.18	22.71	23.02	22.50	24.96
MLF-MW16	36.83	22.16	22.49	22.55	22.90	22.08	21.16	22.50	23.41	23.13	26.09
OBA-01	14.99	4.64	5.24	5.26	5.35	4.75	4.11				
OBA-02	16.06	5.32	5.19	5.23	5.40			6.75	7.38	7.16	
PAAF- MW-04	52.72	29.86	29.83	29.95	29.75						
PAAF- MW-06	52.54	30.46	30.34	30.45	30.24	30.07	29.42	30.92	32.36	32.34	
PAAF-01 (1041)	61.90	30.22	33.66	33.76	30.08						
PAAF-02 (1040)	58.34	30.15	26.62	26.73	29.99		29.16	30.38	32.18	32.30	33.14
PLF-PW-08	63.69	30.89	30.77	30.86	30.60			30.59	32.64	33.06	33.84
PLF-PW-09	38.39	29.66	29.61	29.61	30.31						
PLF-PW-10	34.54	30.00	29.99	29.98	29.81			29.90	31.61	31.93	32.84
PLF-PW-11	43.18	29.20	29.18	29.25	29.16						
PLF-PW-12	34.33	28.08	28.59	28.26	27.35						
PLF-PW-13	39.71	26.05	26.99	27.77	27.63			27.67	27.69	26.77	29.09

Sheet 2 of 7

Water Level Data for APG-AA from 1995 through 1996 (Continued)											
	ELEVATION, FT										
	TOP OF	WATER LEVEL									
WELL / PIEZOMETER	PVC CASING	JAN 95	FEB 95	APR 95	JUN 95	AUG 95	OCT 95	MAR 96	JUN 96	SEP 96	DEC 96
PLF-PW-16	57.60	28.97	28.90	29.47	28.71						
PLF-PW-17	39.34	28.65	28.61	28.64	28.42						
PLF-PW-18	38.58	24.89	25.64	26.39	25.71						
PLF-PW-19	41.77	31.37	32.26	31.68	31.70			32.43	33.34	32.82	34.47
PLF-PW-20	55.03	30.16	30.09	30.20	30.02			29.95	31.93	32.43	33.15
PLF-PW-21	33.58	26.02	25.96	25.92	25.75			25.66	27.35	27.85	28.82
PLF-PW-22A	55.21	29.87	29.82	29.87	29.61			29.55	31.53	31.99	32.81
PLF-PW-22B	55.02	27.91	27.78	27.88	27.60			27.52	29.57	30.06	30.92
PLF-PW-23	37.47	26.91	28.36	28.00	28.94	37.47	37.47	28.63	27.75	26.88	30.05
PLF-PW-24	33.88	26.30	26.96	27.17	26.11	25.32	24.49	27.36	26.73	26.33	30.21
PLP-01	70.85	32.03	31.93	32.13	32.82	31.52	30.89	32.90	34.15	34.61	35.17
PLP-02	65.90	30.97	30.84	31.08	30.79	30.48	29.84	30.74	32.92	33.41	34.00
PLP-03	60.40	20.71	30.58	30.79	30.53	30.19	29.54	30.52	32.55	32.94	33.60
PLP-04	64.46	31.21	31.15	31.27	31.12	30.70	30.10	31.16	33.17	33.52	34.56
PLP-05	38.02	30.61	30.44	30.51	30.30	29.16	29.67	30.72	32.38	32.64	33.70
PLP-06	61.84	23.18	23.10	23.10	22.90	22.53	22.08	22.94	24.60	25.02	26.20
PLP-08	62.93	23.45	23.07	23.41	23.03	22.74	22.15	23.29	25.75	26.19	27.15
PLP-09	68.69	23.60	23.55	23.51	23.17	22.85	22.15	23.14	25.84	26.13	26.31
PLP-10	64.90	17.56	17.48	17.33	17.14	16.92	16.50	17.14	19.05	19.70	20.14
PLP-11	60.66	18.50	18.40	18.32	18.18	17.94	17.58	18.16	19.76	20.26	20.78
PLP-12	63.53	15.53	15.47	15.37	15.21	15.01	14.77	15.01	16.03	16.60	17.09
PLP-13	55.25	35.67	36.05	36.42	37.23	35.35	34.20	36.87	38.64	38.90	41.37
PLP-14	59.31	34.00	34.14	34.31	33.90	33.54	32.86	34.67	36.31	36.69	38.29
PLP-15	71.32	38.01	38.51	38.75	39.32	37.89	36.89	39.26	41.10	41.25	43.32
PLP-16	34.37	15.21	15.15	14.69	14.76	14.56	14.70	15.51	16.79	17.03	17.54
PLP-17	47.42	38.40	38.84	38.87	39.04	37.79	37.08	40.61	41.23	42.25	44.24
PLP-18	52.52				37.50	37.96	36.60	40.47	41.60	41.59	44.85
PLP-19	63.56	35.25	35.22	35.43	35.10	34.64	33.67	35.19	37.94	38.05	39.36
PLP-20	50.03	35.27	35.73	36.05	35.86	34.92	33.85	36.98	38.25	38.62	41.48
PLP-21	57.42	35.41	35.70	36.05	35.83	35.07	33.92	36.22	38.32		
PLP-22	69.74	31.38	31.27	31.68	31.25	30.76	29.84	31.17	33.76	34.03	35.37
PLP-23	65.61	30.20	30.20	30.42	29.98	29.50	28.64	29.91	32.26	32.71	35.16
PLP-24	63.27	33.29	33.19	33.35	33.06	32.65	31.87	32.95	35.47	35.97	37.03
PLP-25	63.38	31.92	31.72	31.65	31.17	30.95	30.22	31.67	34.45	34.60	35.68
PP-02	29.33	18.44	20.18		19.80	17.82	17.13	20.53	20.15	18.75	23.03
SP W-2	17.27	-2.06	-2.33	-2.15	-3.71	0.96	1.04	2.17	2.45	2.45	1.47
SP W-2A	16.95	-1.36	-1.80	-1.71	-3.83	0.59	0.88	1.66	1.90	1.73	0.71
SP W-4	23.63	-1.07	-1.99	-1.72	-2.79	0.30	1.03	1.93	1.47	1.33	1.13
SP W-4A	23.34	-1.58	-1.48	-1.55	-2.38	0.72	0.19	0.64	1.48	1.52	
SP W-5	32.70	-5.90	-6.14	-5.83	-7.24	-4.16	-4.17	2.80	3.12	2.65	20.60
SP W-5A	37.81	3.98	3.78	4.13	3.37	6.31	6.17	2.01	2.35	2.26	1.51
TW2-CB-01	17.13	13.85	13.89	17.13	13.08	11.85	12.15	13.03	13.88	13.63	14.65
WB-MW-01A	46.34				19.03	18.00	17.27	18.55	19.48	18.94	21.83
WB-MW-01B	46.33	16.71	17.63	18.01	18.95	17.86	17.14	18.51	19.33	18.82	20.81
WB-MW-01C	45.98	15.89	17.36	17.81	18.78	17.19	16.48	18.24	18.58	18.10	21.59
WB-MW-02B	44.31	16.57	17.38	17.86	18.85	17.23	16.57	18.28	18.66	18.20	21.68
WB-MW-02C	43.94	15.42	17.33	17.73	18.75	16.92	16.09	18.13	18.12	17.63	21.56

Sheet 3 of 7

Water Level Data for APG-AA from 1995 through 1996 (Continued)

WELL / PIEZOMETER	ELEVATION, FT										
	TOP OF PVC CASING	WATER LEVEL									
		JAN 95	FEB 95	APR 95	JUN 95	AUG 95	OCT 95	MAR 96	JUN 96	SEP 96	DEC 96
WB-MW-03A	43.09	15.37	17.11	17.63	18.70	17.17	16.74	17.86	18.51	18.04	21.45
WB-MW-03B	43.01	14.78	17.29	17.72	18.77	17.09	16.50	18.15	18.48	17.99	21.57
WB-MW-03C	43.54	15.63	17.27	17.69	18.75	17.01	16.42	18.10	18.41	17.92	21.51
WB-MW-04A	43.51	15.68	17.03	17.49	17.90	17.28	16.52	17.79		17.81	21.31
WB-MW-04B	43.38	15.47	17.13	17.57	18.00	17.15	16.35	17.97	18.28	17.78	21.38
WB-MW-04C	43.20	15.37	17.10	17.55	17.98	16.98	16.21	17.88	18.09	17.60	21.30
WB-MW-05A	40.51	12.67	17.40		18.17	17.68	17.14	18.49	20.07	19.67	21.69
WB-MW-05B	40.15	17.05			18.13	17.54	17.03	18.32	19.83	19.43	21.55
WB-MW-05C	40.76	17.76			18.14	17.48	17.00	18.21	19.63	19.24	21.42
WB-MW-06A	42.19	18.32	18.79	19.17	19.55	19.30	18.54	19.99	21.29	20.65	23.01
WB-MW-06B	42.79	18.24	18.73	19.22	19.46	19.32	18.49	19.94	21.33	20.59	23.04
WB-MW-06C	43.41	18.29	18.73	19.13	19.36	19.22	18.38	19.82	21.21	20.45	22.94
WB-MW-07A	43.44	23.02	22.99	23.29	23.54	23.20	22.41	23.59	25.79	25.19	27.46
WB-MW-07B	41.88	22.99	22.98	23.29	23.56	23.20	22.40	24.50	25.78	25.18	27.48
WB-MW-07C	43.83	22.71	22.82	23.14	23.27	23.04	22.18	24.21	25.61	23.90	27.35
WB-MW-08A	49.84				23.80	23.14	22.39	24.51	27.04	26.61	28.52
WB-MW-08B	49.94				23.42	22.97	22.28	24.24	26.22	25.66	27.46
WB-MW-08C	48.33				19.80	21.80	21.14	23.03	24.75	24.24	25.57
WB-MW-09A	40.44	23.40	23.43	23.54	23.62	23.20	22.54	24.60	26.41	25.91	27.64
WB-MW-09B	41.76	23.47	23.49	23.58	23.66	23.23	22.58	24.59	26.41	25.92	27.57
WB-MW-09C	40.53	23.23	23.25	23.36	23.44	23.05	22.40	24.37	26.17	25.67	27.35
WB-MW-10A	40.42	25.37	25.31	25.49	25.64	25.05	24.33	26.96	28.04	26.28	30.12
WB-MW-10B	41.19	24.77	24.77	25.01	25.14	24.70	23.99	26.23	27.51	27.19	29.33
WB-MW-10C	40.99	24.72	24.68	24.95	25.07	24.67	23.95	26.17	27.46	28.18	29.26
WB-MW-11A	46.83	27.33	27.41	27.58	27.59	27.04	26.33	28.48	30.03	29.86	31.77
WB-MW-11B	47.89	27.17	27.26	27.09	27.37	26.88	26.18	28.29	29.87	29.69	31.49
WB-MW-11C	47.53	27.08	27.14	27.23	27.31	26.78	26.11	28.17	29.74	29.57	31.33
WB-MW-12A	42.78	30.30	30.75	31.15	30.78	29.72	29.49	32.94	32.90	32.54	36.36
WB-MW-12B	42.74	30.12	30.28	30.44	30.20	29.51	29.64	31.90	32.31	32.24	34.29
WB-MW-12C	41.91	26.84	27.09	27.23	27.16	26.77	26.38	28.31	29.51	29.31	31.29
WB-MW-13A	63.97	31.55	31.57	31.82	31.66	30.25	30.50	32.00	33.76	33.87	34.72
WB-MW-13B	63.92	31.77	31.81	32.01	31.82	31.40	30.69	32.25	33.90	34.04	34.92
WB-MW-13C	62.68	32.16	32.22	32.44	32.25	31.76	31.07	32.78	34.22	34.37	35.38
WB-MW-14A	45.45	26.15	26.12	26.19	26.21	25.87	25.18	26.65	28.83	28.53	29.47
WB-MW-14B	45.87	25.98	25.99	26.07	26.11	25.72	25.03	26.59	28.71	28.42	29.42
WB-MW-14C	45.80	25.38	25.43	25.10	25.55	25.16	24.45	26.10	28.15	27.84	28.90
WB-MW-15A	39.27	29.08	30.14	30.26	30.48	29.44	27.12	32.76	32.83	30.82	36.17
WB-MW-15B	39.38	23.63	23.70	23.80	23.79	23.34	22.66	24.50	26.38	25.92	27.22
WB-MW-15C	39.36	23.53	23.60	23.69	23.77	23.24	22.56	24.41	26.30	25.84	27.14
WB-MW-16A	28.62					18.07	17.07	20.57	22.22	20.62	24.84
WB-MW-16B	28.55					17.57	16.63	19.60	20.82	20.05	22.37
WB-MW-16C	28.08					13.08	12.80	14.10	15.40	15.22	16.53
WB-MW-17A	26.39				17.84	17.23	16.42	19.03	21.06	20.47	22.45
WB-MW-17B	26.05				16.73	16.18	15.42	17.82	19.37	18.94	20.74
WB-MW-17C	26.44				13.22	12.72	12.38	13.58	14.92	14.76	15.99
WB-MW-18A	32.30				9.79	9.53	9.36	10.34	11.12	10.93	11.68
WB-MW-18B	33.21				10.65	10.30	9.93	11.21	12.05	11.69	12.57

Sheet 4 of 7

Water Level Data for APG-AA from 1995 through 1996 (Continued)											
	ELEVATION, FT										
	TOP OF	WATER LEVEL									
WELL / PIEZOMETER	PVC CASING	JAN 95	FEB 95	APR 95	JUN 95	AUG 95	OCT 95	MAR 96	JUN 96	SEP 96	DEC 96
WB-MW-18C	33.90				7.88	10.28	9.91	11.20	12.04	11.68	12.56
WB-MW-19A	43.43				17.82	17.09	16.50	17.37	18.47	18.13	20.73
WB-MW-19B	43.58				17.86	17.00	16.53	17.28	18.41	18.02	20.75
WB-MW-19C	44.18				17.30	15.63	15.97	15.45	16.58	16.32	19.90
WB-MW-20A	41.44				16.71	17.52	16.08	17.24	18.24	17.68	21.36
WB-MW-20B	41.39				16.65	17.68	16.45	16.79	17.19	17.25	19.89
WB-MW-20C	41.49				16.19	17.75	15.89	17.59	17.94	17.31	19.95
WB-MW-21A	42.70				17.18	17.73	16.71	18.18	19.56	19.25	21.12
WB-MW-21B	42.61				13.56	16.74	14.29	16.51	16.38	15.39	18.06
WB-MW-21C	42.34				12.55	16.55	13.80	16.20	15.54	14.52	17.27
WB-MW-22A	37.92				19.04	19.05	18.48	19.59	21.22	20.98	22.58
WB-MW-22B	37.69				18.29	18.76	17.82	19.01	20.59	20.23	22.15
WB-MW-22C	38.07				12.35	16.65	12.52	15.13	15.99	14.19	18.47
WB-P-01	42.46	20.61	20.68	21.02	21.27	21.06	20.29	22.10	23.41	22.79	25.26
WB-P-02	43.80	19.85	20.04	20.36	20.56	20.39	19.61	21.28	22.66	22.09	24.36
WB-P-03	42.92	19.47	19.60	19.89	20.23	19.86	19.16	20.80	22.17	21.54	23.84
WB-P-04	45.52	17.72	18.26	18.73	18.90	18.86	17.93	19.29	20.73		
WB-P-05	41.50	15.03	17.22	17.67	18.08	17.92	17.23	18.32	19.48	18.96	21.50
WB-P-06	39.08	17.26	17.63	17.92	17.86	17.84	17.30	18.58	19.95	19.53	21.78
WB-P-07	48.54	19.92	19.93	20.26	20.92	20.42	19.78	21.14	22.56	21.03	24.42
WB-P-08	42.48	16.23	17.93	17.37	18.19	17.12	16.94		18.92		21.23
WB-P-09	41.95	17.21	18.26	17.59	18.14	17.57	17.07				
WB-P-10A	42.15				26.07	25.58	24.91	27.29	28.11	27.68	30.77
WB-P-10B	42.76				23.14	23.68	23.21	25.41	25.87	25.25	28.72
WB-P-11A	28.48	19.48	20.40	20.69	20.12	18.46	17.68	20.94	20.78	20.20	22.38
WB-P-11B	28.37	6.52	11.44	11.43	11.44	11.22	11.19	11.87	12.56	12.63	13.03
WB-P-12A	28.30	18.55	19.01	19.14	19.47	18.45	17.74	19.73	19.88	19.16	20.88
WB-P-12B	28.64	20.76	21.86	21.96	22.03	21.38	20.70	22.64	24.28	23.77	25.22
WB-P-13A	30.23	19.73	21.55	22.07	21.56	18.39	16.91	23.61	23.27	21.43	24.78
WB-P-13B	29.68				14.87	14.94	14.41	15.48	16.54	16.43	17.13
WB-P-14A	45.09	33.70	36.54	37.82	37.89	34.47	31.74	39.59	39.19	36.34	40.89
WB-P-14B	47.05					19.24	18.64	22.25	23.61	22.93	24.90
WB-P-15A	21.79				15.97	14.50	13.98	17.77	18.27	16.69	18.41
WB-P-15B	22.19	13.09	13.27	13.58	13.90	15.93	15.64	17.15	18.31	17.96	18.91
WB-P-16A	28.24				18.15	16.31	15.24	19.14	19.01	17.62	20.54
WB-P-16B	27.73				13.87	14.17	15.51	18.03	19.39	18.61	20.48
WB-P-17A	21.39				12.79	11.17	10.54	14.53	15.19	13.12	15.80
WB-P-17B	22.34				11.33	9.69	9.61	11.82	12.26	11.61	12.78
WB-P-18A	25.82				17.70	16.08	14.88	19.37	20.18	18.67	20.79
WB-P-18B	26.28					13.50	12.86	15.50	16.10	15.50	16.98
WB-P-19A	37.97				14.05	13.33	12.50	13.59	15.00	14.33	15.69
WB-P-19B	38.83					12.14	11.64	13.43	14.03	13.49	14.73
WB-P-20A	14.67				6.73	5.72	5.29	8.12	8.42	8.09	10.07
WB-P-20B	14.61				6.85	5.41	5.92	9.71	8.91	7.08	9.58
WB-P-21A	16.11				2.31	1.81	1.45	3.71	4.77	2.97	5.71
WB-P-21B	15.31	1.83	1.41	1.65	1.99	2.01	1.51	3.06	4.03	2.71	4.38
WB-P-22A	37.57				17.67	16.96	16.53	17.52	17.91	18.62	20.99
											Sheet 5 of 7

Water Level Data for APG-AA from 1995 through 1996 (Continued)

WELL / PIEZOMETER	ELEVATION, FT										
	TOP OF PVC CASING	WATER LEVEL									
		JAN 95	FEB 95	APR 95	JUN 95	AUG 95	OCT 95	MAR 96	JUN 96	SEP 96	DEC 96
WB-P-22B	38.11	15.46	15.06	15.25	15.70	15.56	15.70	15.78	17.03	16.79	19.71
WES-M-01	34.61	21.86	22.00	22.86	23.18	21.95	20.87	22.61	23.46	22.87	25.21
WES-M-02	36.43	21.80	22.18	22.72	23.12	22.18	21.16	22.38	23.47	23.00	25.19
WES-M-03	36.35	21.63	22.05	22.45	22.82	21.73	20.64	22.15	23.22	22.81	25.09
WES-M-04	36.45	19.86	20.29	20.54	20.84	19.87	18.89	20.73	21.49	21.13	22.89
WES-M-05	37.77	22.13	22.60	22.72	23.44	22.73	21.75	22.47	23.69	23.43	25.43
WES-M-06	37.15	21.57	21.96	22.22	22.74	21.67	20.60	22.25	23.13	22.75	25.01
WES-M-07	37.01	19.94	20.31	20.63	20.88	19.92	19.00	20.81	21.63	21.21	22.86
WES-M-08	36.02	21.81	22.15	22.70	22.89	21.60	20.45	22.62	23.25	22.64	30.24
WES-M-10	28.51	21.61	22.00	22.13	22.32	20.79	19.52	22.76	22.83	22.36	25.95
WES-M-11	28.85	21.37	21.78	21.92	22.24	20.78	19.54	22.49	22.73	22.27	25.65
WES-M-12	28.95	19.01	19.38	19.67	19.88	18.98	18.06	19.97	20.67	20.29	21.97
WES-M-13	28.78	21.43	21.85	21.98	22.26	20.76	19.50	22.58	23.74	22.28	25.74
WES-M-14	29.38	21.36	21.76	22.02	22.36	20.97	19.76	22.51	22.86	22.38	25.79
WES-M-15	30.42	21.28	21.72	21.86	22.20	20.81	19.60	22.32	22.69	22.27	25.52
WES-M-16	30.61	19.42	19.86	20.06	20.39	19.41	18.44	20.32	21.09	20.71	22.57
WES-M-17	30.42	21.35	21.74	22.04	22.41	21.05	19.87	22.51	22.90	22.47	25.87
WES-M-18	32.04	21.53	21.92	22.34	22.72	21.74	20.61	22.40	23.28	22.80	25.74
WES-M-19	31.74	21.46	21.83	22.20	22.50	21.42	20.31	23.42	23.06	22.72	23.70
WES-M-20	31.57	19.69	20.12	20.31	20.65	19.66	18.71	20.68	21.37	20.98	22.87
WES-M-21	35.54	21.56	22.20	22.41	22.82	21.90	20.82	22.34	23.32	22.88	25.60
WES-M-22	30.81	21.23	21.71	21.87	22.11	20.89	19.70	22.51	22.80	22.39	26.07
WES-M-23	30.90	21.23	21.68	21.85	22.36	20.87	19.67	22.48	22.78	22.38	26.06
WES-M-24	32.16	21.22	21.74	21.73	22.14	20.56	19.30	22.48	22.61	22.18	25.89
WES-M-25	32.17	21.00	21.46	21.51	21.97	20.49	19.31	21.97	22.43	22.07	25.64
WES-M-26	38.64	22.77	23.38	23.69	24.38	23.40	22.26	23.30	24.50	24.10	26.03
WES-M-27	38.57	21.71	22.15	22.50	22.92	21.89	20.83	22.29	23.27	22.87	24.72
WES-M-28	38.46	20.96	21.33	21.67	21.92	21.08	20.06	21.46	22.54	22.18	23.66
WES-M-29	28.49	22.26	22.73	22.77	22.48	20.87	20.01	22.91	22.79	22.43	24.73
WES-M-30	28.51	21.00	21.97	22.07	22.02	20.53	19.53		23.46	21.95	24.13
WES-M-31	28.36	18.89	19.26	19.65	19.82	18.92	17.95	19.69	20.56	20.18	21.51
WES-M-32	33.20	21.34	21.90	21.80	22.02	20.18	18.92	22.62	22.42	21.96	25.60
WES-M-33	33.03	20.91	21.43	21.35	21.68	20.10	18.93	21.63	22.21	21.79	25.09
WES-M-34	32.95	18.54	19.00	19.24	19.44	18.54	17.63	19.42	20.27	19.87	25.45
WES-M-35	31.37	20.74	21.15	21.22	21.74	20.23	19.06	22.01	22.23	21.89	25.63
WES-M-36	31.31	20.83	21.16	21.33	21.81	20.33	19.17	23.11	22.29	21.99	25.76
WES-M-37	31.20	16.73	17.18	17.14	17.47	16.85	16.34	17.62	18.56	18.38	19.15
WES-M-38	36.31	21.70	22.23	22.45	22.93	21.83	20.81	22.76	23.41	23.23	26.35
WES-M-39	36.88	21.49	21.98	22.26	22.74	21.55	20.49	22.70	23.22	23.00	26.30
WES-M-40	37.82	19.82	20.27	20.37	20.70	19.75	18.81	20.42	21.38	21.12	23.14
WES-M-41	38.43	22.29	22.63	23.04	23.39	22.74	21.89	22.77	23.81	23.68	25.79
WES-M-42	38.72	22.04	22.46	22.76	23.14	22.37	21.43	22.52	23.59	23.41	25.48
WES-M-43	38.77	20.05	20.47	20.62	20.95	20.00	19.04	20.92	21.61	21.31	23.23
WES-PZS-01	32.48	23.36	23.50	24.67	24.99	22.90	21.44	24.12	24.56	23.68	28.68
WES-PZS-02	24.30	21.01	21.66	21.52	21.46	19.56	18.55	21.96	21.70	21.24	24.00
WES-PZS-03	37.85	22.23	22.75	23.44	24.14	22.63	21.33	23.66	24.09	23.12	26.41
WES-PZS-04	33.44	22.31	23.20	23.86	24.30	22.30	20.88	23.65	24.12	23.02	27.44

Sheet 6 of 7

Water Level Data for APG-AA from 1995 through 1996 (Concluded)											
	ELEVATION, FT										
	TOP OF	WATER LEVEL									
WELL / PIEZOMETER	PVC CASING	JAN 95	FEB 95	APR 95	JUN 95	AUG 95	OCT 95	MAR 96	JUN 96	SEP 96	DEC 96
WES-PZS-05	33.07	21.26	21.71	21.96	22.51	21.14	20.05	22.42	22.83	22.59	26.05
WES-PZS-06	32.50				22.82	22.08		22.28	23.27	23.10	24.18
WES-PZD-06	32.60					7.88	10.54	11.01	11.66	11.80	12.14
WES-PZS-07	30.82				23.90	21.89	20.93	24.80	23.86	22.77	26.80
WES-PZD-07	31.43					11.82	12.35	13.07	13.77	13.83	14.29
WES-PZS-08	37.37				26.38	25.46	25.00	27.41	26.53	26.33	28.40
WES-PZD-08	37.87				15.08	16.55	13.99	14.62	15.41	15.52	15.85
WOODREST CK-01	14.46	2.90	2.97	3.12	3.24	2.88	2.87	3.94	4.14	3.96	5.30
X-01	11.24	9.17	9.14	9.26	9.41	9.20	9.06	9.34	9.82	9.94	10.14
X-02	17.29	8.97	8.88	9.28	9.39	8.97	8.84	9.19	9.59	9.69	9.91
											Sheet 7 of 7

Appendix C
Well Screen Depths

The top and bottom of the well screens are depth from ground surface. Note some of the wells have multiple screens. Appendix C includes several off-post and on-post wells that are not included in Appendix B or Appendix D.

Well Screen Depths				
ROW #	NAME	DEPTH FROM GROUND SURFACE, FT		MULTIPLE SCREENS IN WELL
		TOP SCREEN	BOTTOM SCREEN	
1	1-69	33.0	43.0	
2	2-69	45.0	66.0	
3	2-76	208.0	218.0	Yes
4	2-76	147.0	167.0	Yes
5	3-69	44.0	50.0	
6	3-76	223.0	228.0	Yes
7	3-76	150.0	155.0	Yes
8	4-68	81.8	92.3	
9	4-69	44.0	65.0	
10	4-70	70.0	97.0	
11	4-76A	155.0	165.0	Yes
12	4-76A	125.0	140.0	Yes
13	4-76B	55.0	66.0	Yes
14	4-76B	40.0	50.0	Yes
15	5-70	91.0	107.0	Yes
16	5-70	149.0	166.0	Yes
17	5-76	134.0	143.0	
18	6-70	60.0	66.0	Yes
19	6-70	77.0	107.0	Yes
20	6-76	151.0	161.0	
21	8-70	60.0	89.0	
22	AA 01	24.0	71.0	
23	AA 02	17.0	41.0	
24	AA 03	30.0	61.0	
25	AA 04	7.0	47.0	
26	AA 05	34.0	49.0	
27	AA WW01	30.0	60.0	
28	B 0340 A	11.9	36.5	
29	B 0340 B	22.0	36.7	
30	B 0340 C	22.3	37.0	
31	B 0525 MW01	15.0	25.0	
32	B 0525 MW02	13.0	23.5	
33	B 0525 MW03	14.0	24.0	
34	B 0525 MW04	15.0	25.0	
35	B 0525 MW05	13.0	23.0	
36	B 0525 MW06	12.5	22.3	
37	B 0525 MW07	15.0	25.0	
38	B 0525 MW08	16.0	26.0	
39	B 0525 MW09	17.0	26.7	
40	B 0525 MW10	17.0	27.0	
41	B 1047 MW04	16.0	30.0	
42	B 1047 MW05	16.0	30.0	
43	B 1047 MW06	16.0	30.0	
44	B 1047 MW07	16.0	30.0	
45	B 1047 MW08	20.0	35.0	
46	B 1047 MW09	20.0	35.0	
47	B 1047 MW10	20.0	35.0	
48	B 1047 MW11	20.0	35.0	
				Sheet 1 of 10

Well Screen Depths (Continued)

ROW #	NAME	DEPTH FROM GROUND SURFACE, FT		MULTIPLE SCREENS IN WELL
		TOP SCREEN	BOTTOM SCREEN	
49	B 2378	42.0	57.0	
50	B 2515 CG01	38.0	52.0	
51	B 2831 A	21.3	36.0	
52	B 2831 B	19.1	33.8	
53	B 2831 C	24.4	39.0	
54	B 3011 MW01	7.0	15.5	
55	B 3011 MW02	7.5	16.3	
56	B 3011 MW03	7.0	16.2	
57	B 3070A MW01	3.0	19.0	
58	B 3070A MW02	3.0	17.5	
59	B 3070A MW03	3.0	17.3	
60	B 4001	6.8	21.4	
61	B 4020	3.9	18.5	
62	B 4020 MW03	5.3	20.0	
63	B 4020 MW04	5.0	20.0	
64	B 4020 MW08	5.0	20.0	
65	B 4020 MW09	3.0	20.0	
66	B 4021 A	5.0	19.0	
67	B 4021 B	5.0	19.0	
68	B 4021 C	5.0	19.8	
69	B 4021 D	4.0	18.2	
70	B 4021 MW02	5.0	19.0	
71	B 4021 MW04	4.5	18.2	
72	B 4025	5.0	22.2	
73	B 4027 MW02	12.5	27.0	
74	B 4027 MW04	7.0	22.0	
75	B 4027 MW06	8.3	23.0	
76	B 4027 T	8.0	23.0	
77	B 4029	5.0	20.5	
78	B 4119 MW01	7.0	16.1	
79	B 4119 MW02	7.5	17.0	
80	B 4119 MW03	7.5	16.8	
81	B 4726	32.0	47.0	
82	B 5043	2.0	16.0	
83	B 5043 MW02	2.0	15.8	
84	B 5043 MW03	2.0	16.2	
85	B 5051 MW01	2.0	10.3	
86	B 5051 MW02	2.0	10.6	
87	B 5051 MW03	2.0	10.4	
88	B 5051 MW04	2.0	10.3	
89	B 5201	8.0	21.0	
90	B 5206	2.5	16.5	
91	B 5206 MW02	2.5	16.0	
92	B 5206 MW03	2.7	17.0	
93	B 5222	4.0	19.0	
94	B 5413	12.5	22.0	
95	B 5413 MW02	15.2	24.0	
96	B 5413 MW03	12.5	21.4	

Sheet 2 of 10

Well Screen Depths (Continued)

ROW #	NAME	DEPTH FROM GROUND SURFACE, FT TOP SCREEN	BOTTOM SCREEN	MULTIPLE SCREENS IN WELL
97	B 5454 MW01	2.0	10.0	
98	B 5454 MW02	2.0	10.5	
99	B 5454 MW03	2.0	8.5	
100	B-3-1	12.3	22.3	
101	B-3-2	5.0	15.0	
102	B-3-3	8.0	18.0	
103	B-3-4	6.0	16.0	
104	B-3-5	8.0	18.0	
105	B-3-6	4.0	14.0	
106	B3-CB-1	14.0	24.0	
107	B3-CB-2	13.5	23.5	
108	B3-CB-3	13.0	23.0	
109	BTD-1	14.5	24.5	
110	BTD-2	9.0	19.0	
111	BTD-3	5.0	15.0	
112	BTD-4	5.0	15.0	
113	CAP 01	49.0	72.0	
114	CAP 02	39.0	60.0	
115	CAP 03	41.0	63.0	
116	CAP 04	27.0	54.0	
117	CAP 05	27.0	52.8	
118	CAP 06	29.0	47.0	
119	CAP 07	51.0	66.3	
120	CAP 08	49.9	80.0	
121	CAP 09	53.0	68.0	
122	CAP 10	58.0	73.0	
123	CITY 02	37.0	42.0	
124	CITY 04	49.0	54.0	
125	CITY 05	42.0	47.0	
126	CITY 06	39.3	44.7	
127	CITY 07	54.0	65.0	
128	CITY 09	57.0	72.5	
129	CITY 10	55.0	75.0	
130	DM BOR102	41.5	51.5	
131	DM BOR103	58.0	68.0	
132	DM BOR106	40.0	50.0	
133	DM BOR107	23.0	33.0	
134	DM BOR110	70.0	80.0	
135	FF-1	8.0	18.0	
136	FF-2	7.0	17.0	
137	FF-3	7.0	17.0	
138	FF-4	7.0	17.0	
139	FTA M01	20.5	30.5	
140	FTA M02	17.0	27.0	
141	FTA M03	15.0	25.0	
142	FTA M04	20.0	30.0	
143	FTA M05	24.0	34.0	
144	FTA M06	24.0	34.0	

Sheet 3 of 10

Well Screen Depths (Continued)

ROW #	NAME	DEPTH FROM GROUND SURFACE, FT TOP SCREEN	BOTTOM SCREEN	MULTIPLE SCREENS IN WELL
145	FTA M07	22.5	32.5	
146	FTA M08	22.5	32.5	
147	FTA M09	22.5	32.5	
148	FTA M10	27.0	37.0	
149	FTA M11	15.0	25.0	
150	FTA M12	16.5	26.5	
151	FTA MD07	66.0	75.5	
152	FTA MD13	62.5	72.5	
153	FTA PZ01	22.5	27.5	
154	FTA PZ02	15.0	20.0	
155	FTA PZ03	22.5	27.5	
156	FTA PZ04	16.0	21.0	
157	FTA PZ05	27.5	32.5	
158	FTA PZ06	20.5	25.5	
159	FTA PZ07	36.0	41.0	
160	FTA PZ08	31.0	36.0	
161	FTA PZ09	24.0	29.0	
162	FTA PZ10	38.0	43.0	
163	FTA PZ11	38.0	43.0	
164	FTA PZ12	26.0	31.0	
165	FTA PZ13	35.0	40.0	
166	FTA PZ14	26.0	31.0	
167	FTA PZ15	20.5	25.5	
168	FTA PZ16	27.5	32.5	
169	FTA PZ17	25.0	30.0	
170	G-1	14.0	24.0	
171	GM 01	155.0	165.0	
172	GM 02	55.0	65.0	
173	GM 03	200.0	210.0	
174	GM 04	65.0	75.0	
175	GM 05	168.0	178.0	
176	GM 06	85.0	95.0	
177	GM 07	126.0	136.0	
178	GM 08	60.0	70.0	
179	GM 09	30.0	40.0	
180	GM 10	60.0	70.0	
181	GM 11	70.0	80.0	
182	GM 12	65.0	75.0	
183	GM 13	113.0	123.0	
184	GM 14	35.0	45.0	
185	GM 15	108.0	118.0	
186	GM 16	40.0	50.0	
187	HA 700086	96.0	144.0	
188	HA 720433	65.0	70.0	
189	HA 735410 (B 1135)	60.0	70.0	
190	HA 810061 (B 899)	95.0	106.0	
191	HA 810062 (B1191)	215.0	225.0	
192	HA 810063	170.0	180.0	

Sheet 4 of 10

Well Screen Depths (Continued)

ROW #	NAME	DEPTH FROM GROUND SURFACE, FT		MULTIPLE SCREENS IN WELL
		TOP SCREEN	BOTTOM SCREEN	
193	HA 810244	144.0	158.0	
194	HA 810978	147.0	157.0	
195	HA 810978	87.0	100.0	
196	HA 810978	170.0	189.0	
197	HA 811140	50.0	65.0	
198	HA 813093 (B 1197A)	115.0	125.0	
199	HA 881459	30.0	30.0	
200	HA 881460	20.0	30.0	
201	HA 881593	105.0	115.0	
202	HA 920161	83.0	113.0	
203	HA DE 060 (BG&E)	160.0	180.0	Yes
204	HA DE 060 (BG&E)	194.0	207.0	Yes
205	HA DE 060 (BG&E)	92.0	100.0	Yes
206	HA DE 150	95.0	100.0	
207	HA DE 164	115.0	120.0	
208	HA DE 165	153.0	158.0	
209	HA DE 166	131.0	140.0	
210	HA DE 169	50.0	60.0	
211	HA DE 197	75.0	85.0	
212	HA DF 040 (HA 811641)	421.5	431.5	
213	HA DF 07	125.0	137.0	
214	HA DF 08	147.0	165.0	
215	HA DF 09	83.0	88.0	
216	HA DF 10	133.5	138.5	Yes
217	HA DF 10	146.0	156.5	Yes
218	HA DF 11	39.5	52.0	
219	HCP 01	94.0	103.0	
220	HCP 02	113.0	133.0	
221	HCP 03	102.0	133.0	
222	HCP 04	108.0	129.0	
223	HCP 05	60.0	89.0	
224	HCP 06	60.0	66.0	Yes
225	HCP 06	77.0	107.0	Yes
226	HCP 08	112.0	137.0	
227	HCP 09	55.0	79.0	Yes
228	HCP 09	84.0	91.5	Yes
229	MGS 07A	35.0	45.0	
230	MLF MW01	20.0	25.0	Yes
231	MLF MW01	30.0	35.0	Yes
232	MLF MW01	10.0	15.0	Yes
233	MLF MW02	13.0	18.0	Yes
234	MLF MW02	31.0	36.0	Yes
235	MLF MW03	12.0	22.0	
236	MLF MW04	12.3	17.3	
237	MLF MW05	25.6	35.6	Yes
238	MLF MW05	6.6	11.6	Yes
239	MLF MW06	9.5	24.5	
240	MLF MW07	23.0	28.0	Yes

Sheet 5 of 10

Well Screen Depths (Continued)

ROW #	NAME	DEPTH FROM GROUND SURFACE, FT TOP SCREEN	BOTTOM SCREEN	MULTIPLE SCREENS IN WELL
241	MLF MW07	7.0	17.0	Yes
242	MLF MW16	18.0	23.0	
243	P-1 (HA DF 07)	107.5	109.5	Yes
244	P-1 (HA DF 07)	132.0	145.0	Yes
245	P-2 (HA DF 09)	84.0	90.0	Yes
246	P-2 (HA DF 09)	142.0	152.5	Yes
247	P-3 (HA DF 10)	149.0	161.5	Yes
248	P-3 (HA DF 10)	94.0	96.0	Yes
249	P-3 (HA DF 10)	137.0	142.0	Yes
250	P-4 (HA DF 11)	45.0	52.5	Yes
251	P-4 (HA DF 11)	35.0	40.0	Yes
252	P-5 (HA DF 08)	151.0	169.0	Yes
253	P-5 (HA DF 08)	95.0	97.0	Yes
254	PAAF 01	71.0	81.0	
255	PAAF 02	73.0	83.0	
256	PLP 01	35.5	50.0	
257	PLP 02	30.0	44.5	
258	PLP 03	24.0	39.0	
259	PLP 04	25.0	40.0	
260	PLP 05	10.0	25.0	
261	PLP 06	33.0	48.0	
262	PLP 07	32.5	48.0	
263	PLP 08	36.0	56.0	
264	PLP 09	34.0	51.0	
265	PLP 10	40.0	55.0	
266	PLP 11	35.0	50.0	
267	PLP 12	40.0	55.0	
268	PLP 13	12.0	27.0	
269	PLP 14	18.0	33.0	
270	PLP 15	25.5	40.0	
271	PLP 16	147.0	162.0	
272	PLP 17	12.0	17.0	
273	PLP 18	12.5	17.5	
274	PLP 19	42.5	47.5	
275	PLP 20	26.5	31.5	
276	PLP 21	32.5	37.5	
277	PLP 22	48.0	53.0	
278	PLP 23	37.5	44.0	
279	PLP 24	37.5	45.5	
280	PLP 25	43.5	48.5	
281	PM 01D	123.0	133.0	
282	PM 02D	170.0	180.0	
283	PM 03D	136.0	150.0	
284	PM 04D	151.0	161.0	
285	PM 05D	250.0	260.0	
286	PP-2	8.0	18.0	
287	PP-3	14.0	24.0	
288	PP-4	14.0	24.0	

Sheet 6 of 10

Well Screen Depths (Continued)

ROW #	NAME	DEPTH FROM GROUND SURFACE, FT TOP SCREEN	BOTTOM SCREEN	MULTIPLE SCREENS IN WELL
289	PW 08	37.0	47.0	
290	PW 09	27.0	38.2	
291	PW 10	11.0	21.0	
292	PW 11	13.0	23.0	
293	PW 12	14.0	29.0	
294	PW 14	28.4	33.3	
295	PW 15	20.0	25.0	
296	PW 16	35.0	45.0	
297	PW 17	21.0	31.0	
298	PW 18	53.0	68.0	
299	PW 19	4.9	16.1	
300	PW 20	12.5	29.1	
301	PW 21	43.0	71.0	
302	PW 22A	24.0	34.0	
303	PW 22B	65.0	75.0	
304	PW 23	5.5	16.5	
305	PW 24	8.0	18.0	
306	SITE 01	54.0	65.0	
307	SITE 02	50.0	80.0	
308	SITE 03	57.0	72.5	
309	SITE 04	49.0	64.2	
310	SITE 05	55.0	75.0	
311	SITE 06	32.0	42.0	
312	SP M01P	160.0	180.0	
313	SP M02D	150.0	170.0	
314	TW2-CB-1	3.0	13.0	
315	TW2-CB-2	8.0	18.0	
316	WB MW01A	27.0	42.5	
317	WB MW01B	62.5	77.0	
318	WB MW01C	82.5	102.5	
319	WB MW02B	72.5	89.5	
320	WB MW02C	92.5	107.5	
321	WB MW03A	27.5	42.5	
322	WB MW03B	77.5	87.5	
323	WB MW03C	93.0	108.0	
324	WB MW04A	27.5	42.5	
325	WB MW04B	65.0	80.0	
326	WB MW04C	85.0	100.0	
327	WB MW05A	15.5	30.5	
328	WB MW05B	76.5	86.5	
329	WB MW05C	136.5	146.5	
330	WB MW06A	19.5	34.5	
331	WB MW06B	59.5	69.5	
332	WB MW06C	97.0	107.0	
333	WB MW07A	14.5	29.5	
334	WB MW07B	54.5	64.5	
335	WB MW07C	99.5	109.5	
336	WB MW08A	18.0	33.0	

Sheet 7 of 10

Well Screen Depths (Continued)

ROW #	NAME	DEPTH FROM GROUND SURFACE, FT		MULTIPLE SCREENS IN WELL
		TOP SCREEN	BOTTOM SCREEN	
337	WB MW08B	64.5	74.5	
338	WB MW08C	133.0	143.0	
339	WB MW09A	11.5	26.5	
340	WB MW09B	79.1	89.1	
341	WB MW09C	109.5	119.5	
342	WB MW10A	9.5	24.5	
343	WB MW10B	76.5	86.5	
344	WB MW10C	109.0	119.0	
345	WB MW11A	14.5	29.5	
346	WB MW11B	69.5	79.5	
347	WB MW11C	107.2	117.2	
348	WB MW12A	7.5	22.5	
349	WB MW12B	34.5	44.5	
350	WB MW12C	94.0	104.0	
351	WB MW13A	24.5	39.5	
352	WB MW13B	69.5	79.5	
353	WB MW13C	115.5	125.5	
354	WB MW14A	13.5	28.5	
355	WB MW14B	74.0	84.0	
356	WB MW14C	155.5	165.5	
357	WB MW15A	9.5	24.5	
358	WB MW15B	111.0	121.0	
359	WB MW15C	161.5	171.5	
360	WB MW16A	5.0	20.0	
361	WB MW16B	101.5	111.5	
362	WB MW16C	199.0	209.0	
363	WB MW17A	6.0	21.0	
364	WB MW17B	65.5	75.5	
365	WB MW17C	147.5	157.5	
366	WB MW18A	18.0	33.0	
367	WB MW18B	80.0	90.0	
368	WB MW18C	105.5	115.5	
369	WB MW19A	19.5	34.5	
370	WB MW19B	49.0	59.0	
371	WB MW19C	128.5	138.5	
372	WB MW20A	20.0	35.0	
373	WB MW20B	78.5	88.5	
374	WB MW20C	136.0	146.0	
375	WB MW21A	20.0	35.0	
376	WB MW21B	98.0	108.0	
377	WB MW21C	151.0	161.0	
378	WB MW22A	19.0	34.0	
379	WB MW22B	54.5	64.5	
380	WB MW22C	136.0	146.0	
381	WB P01	40.0	50.0	
382	WB P02	75.0	80.0	
383	WB P03	58.0	63.0	
384	WB P04	75.0	80.0	

Sheet 8 of 10

Well Screen Depths (Continued)				
ROW #	NAME	DEPTH FROM GROUND SURFACE, FT		MULTIPLE SCREENS IN WELL
		TOP SCREEN	BOTTOM SCREEN	
385	WB P05	62.0	67.0	
388	WB P08	75.0	80.0	
389	WB P09	75.0	80.0	
390	WB P10A	19.0	24.0	
391	WB P10B	109.5	114.5	
392	WB P11A	15.0	20.0	
393	WB P11B	208.5	213.5	
394	WB P12A	18.0	23.0	
395	WB P12B	140.5	145.5	
396	WB P13A	17.0	22.0	
397	WB P13B	187.5	192.5	
398	WB P14A	12.0	17.0	
399	WB P14B	85.5	90.5	
400	WB P15A	13.0	18.0	
401	WB P15B	261.5	266.5	
402	WB P16A	14.0	19.0	
403	WB P16B	15.0	160.0	
404	WB P17A	12.0	17.0	
405	WB P17B	103.5	108.5	
406	WB P18A	10.0	15.0	
407	WB P18B	110.0	115.0	
408	WB P19A	30.0	35.0	
409	WB P19B	126.0	131.0	
410	WB P20A	14.5	19.5	
411	WB P20B	91.5	96.5	
412	WB P21A	17.5	22.5	
413	WB P21B	102.5	107.5	
414	WB P22A	37.0	42.0	
415	WB P22B	114.5	119.5	
416	WELL 120	80.0	85.0	yes
417	WELL 120	87.0	98.0	yes
418	WES M01	13.0	18.0	
419	WES M02	12.0	17.0	
420	WES M03	34.8	39.8	
421	WES M04	109.0	119.0	
422	WES M05	0.0	18.5	
423	WES M06	35.3	40.3	
424	WES M07	109.0	119.0	
425	WES M08	9.0	14.0	
426	WES M09	4.8	9.8	
427	WES M10	8.5	13.5	
428	WES M11	36.5	41.5	
429	WES M12	120.0	130.0	
430	WES M13	9.0	14.0	
431	WES M14	11.5	16.5	
432	WES M15	36.3	41.3	
433	WES M16	109.0	119.0	
434	WES M17	10.0	15.0	
				Sheet 9 of 10

Well Screen Depths (Concluded)

ROW #	NAME	DEPTH FROM GROUND SURFACE, FT		MULTIPLE SCREENS IN WELL
		TOP SCREEN	BOTTOM SCREEN	
435	WES M18	9.8	14.8	
438	WES M21	10.0	15.0	
439	WES M22	9.5	14.5	
440	WES M23	18.0	23.0	
441	WES M24	12.5	17.5	
442	WES M25	34.9	39.9	
443	WES M26	14.5	24.5	
444	WES M27	33.5	43.5	
445	WES M28	74.1	84.1	
446	WES M29	5.0	15.0	
447	WES M30	30.5	40.5	
448	WES M31	99.7	109.7	
449	WES M32	10.9	20.9	
450	WES M33	31.0	41.0	
451	WES M34	104.5	114.5	
452	WES M35	8.0	18.0	
453	WES M36	28.0	38.0	
454	WES M37	129.5	139.5	
455	WES M38	10.6	20.6	
456	WES M39	23.1	33.1	
457	WES M40	95.5	105.5	
458	WES M41	12.2	22.2	
459	WES M42	30.3	40.3	
460	WES M43	102.5	112.5	
461	WES PZD06	146.0	151.0	
462	WES PZD07	156.0	161.0	
463	WES PZD08	155.0	160.0	
464	WES PZS01	6.0	11.0	
465	WES PZS02	5.0	20.0	
466	WES PZS03	8.5	23.5	
467	WES PZS04	3.5	18.5	
468	WES PZS05	5.5	20.5	
469	WES PZS06	27.5	32.5	
470	WES PZS07	10.0	15.0	
471	WES PZS08	12.0	17.0	

Sheet 10 of 10

Appendix D
Coordinate Data

The horizontal coordinates (eastings and northings) are in the UTM NAD-83 survey system. The vertical coordinates (ground surface or top of well casing) are in the NAVD-88 survey system.

Survey data for wells, piezometers, and borings are on pages D2 through D9. Digitized horizontal (eastings and northings) and estimated vertical (ground surface) coordinates are on pages D10 through D14.

Surveyed Coordinate Data

ROW #	TYPE	NAME	STATE PERMIT NUMBER	UTM, FT (NAD-83) X (EASTING)	UTM, FT (NAD-83) Y (NORTHING)	ELEV., FT (NAVD-88) GROUND SURFACE	ELEV., FT (NAVD-88) TOP PVC RISER
1	W	2-69	HA690394	1308738.82	14343101.56	67.8	69.60
2	W	2-76	HA732531	1301662.47	14332643.68	39.4	40.53
3	W	3-76	HA732533	1301563.13	14332053.61	39.0	41.98
4	W	4-70	HA710412	1303487.85	14334712.82	42.6	43.54
5	W	4-76A	HA732535	1301464.77	14331460.88	37.9	39.29
6	W	4-76B	HA732534	1301467.06	14331469.96	37.9	38.60
7	W	5-76	HA732530	1301365.45	14330869.29	38.3	41.64
8	W	6-70		1303112.48	14334104.17	41.0	41.83
9	W	6-76	HA732532	1301232.11	14330080.69	34.7	37.76
10	W	8-70		1302903.75	14333763.57	40.1	40.41
11	W	AA-01	HA811460	1313554.00	14339301.00	61.1	61.21
12	W	AA-02	HA811461	1312847.78	14342004.13	55.4	57.90
13	W	AA-03	HA811459	1312752.83	14345469.31	73.3	75.24
14	W	AA-04	HA811463	1310253.39	14343695.93	50.4	52.20
15	W	AA-05	HA811462	1316348.72	14345160.99	69.8	69.00
16	W	AA-WW-1	HA930702	1309111.00	14341751.00	62.9	62.37
17	W	B-3-1		1318525.84	14325303.87	12.4	14.15
18	W	B-3-2		1316666.02	14322648.06	16.0	18.11
19	W	B-3-3		1313285.48	14317082.58	9.6	10.89
20	W	B-3-4		1317450.00	14323338.00	17.7	17.73
21	W	B-3-5		1314180.53	14319028.45	15.0	16.08
22	W	B-3-6		1312795.01	14316244.64	8.1	9.36
23	W	B1142MW01	HA882184	1339007.99	14330981.87	5.6	7.11
24	W	B2378A	HA881480	1320660.95	14341924.63	58.1	61.37
25	W	B2831MW02	HA881670	1316190.51	14346646.52	57.1	56.89
26	W	B3-CB-1	HA881027	1319680.02	14327349.60	33.5	
27	W	B3-CB-2		1319854.96	14327044.26	22.2	23.63
28	W	B3-CB-3		1320097.32	14327031.39	27.6	29.18
29	W	B3070A#1	HA881697	1322078.13	14338264.63	33.8	36.41
30	W	B3329	HA881649	1319865.27	14341017.87	56.0	58.60
31	W	B340C	HA881644	1326549.57	14337010.45	32.2	34.98
32	W	B4020MW03	HA881938	1322155.50	14337362.27	37.7	40.06
33	W	B4201MW02	HA881780	1321339.54	14337944.02	33.6	36.22
34	W	B445MW01	HA881844	1328324.87	14333921.64	15.6	19.00
35	W	B4726MW05	HA881483	1314454.93	14341913.87	63.5	66.39
36	W	B5222	HA881650	1319335.15	14338084.14		34.81
37	W	B615	HA881912	1328626.19	14327664.61	23.0	24.39
38	W	BTD-1		1313247.78	14324882.48	31.3	33.45
39	W	BTD-2		1313482.19	14323178.68	21.9	
40	W	BTD-3		1313722.53	14323251.69	18.7	
41	W	BTD-4		1313892.36	14323419.64	17.7	
42	W	BURN #1		1290421.79	14306842.55	13.7	14.99
43	W	BURN #2		1290550.21	14306657.27	13.3	16.06
44	W	BURN #4		1290755.88	14306643.04	13.1	14.97
45	W	CITY 01	HA75004	1311764.37	14347109.85		71.85
46	W	CITY 02	HA650540	1311201.67	14346505.75		56.09
47	W	CITY 03		1310746.68	14345771.14		59.37
48	W	CITY 04	HA650540	1310527.74	14345327.81		58.70

Sheet 1 of 8 (Surveyed data) Sheet 1 of 13 (Appendix D)

Coordinate Data - Surveyed (Continued)

ROW #	TYPE	NAME	STATE PERMIT NUMBER	UTM, FT (NAD-83) X (EASTING)	UTM, FT (NAD-83) Y (NORTHING)	ELEV., FT (NAVD-88) GROUND SURFACE	ELEV., FT (NAVD-88) TOP PVC RISER
49	W	CITY 05	HA650540	1310261.19	14344954.06		55.42
50	W	CITY 06	HA650540	1311639.06	14345938.79		58.36
51	W	CITY 07	HA732481	1314482.15	14342862.52		65.92
52	W	CITY 09	HA732483	1315423.46	14344029.09		73.27
53	W	CITY 10	HA732485	1315131.91	14344744.34		67.00
54	W	CSTA TRK	HA880012	1305236.67	14330032.07	33.4	34.40
55	W	FF-1	HA881005	1302319.43	14315109.58	15.6	17.52
56	W	FF-2		1303235.22	14313809.30	13.9	16.60
57	W	FF-3		1303565.98	14314307.65	15.8	18.02
58	W	FF-4		1303438.40	14314669.20	18.3	20.50
59	W	FTA-M01	HA880755	1309877.27	14337384.83	58.2	59.81
60	W	FTA-M02	HA880698	1309762.20	14337878.35	54.1	55.92
61	W	FTA-M03	HA880699	1310273.50	14337793.37	56.9	58.67
62	W	FTA-M04	HA880700	1310273.38	14337772.09	56.8	58.92
63	W	FTA-M05	HA880701	1310391.17	14337424.55	60.8	62.55
64	W	FTA-M06	HA880702	1310236.50	14337304.71	60.7	62.48
65	W	FTA-M07	HA880756	1310078.66	14337201.62	59.3	60.92
66	W	FTA-M08	HA880757	1309913.54	14337062.08	59.0	61.39
67	W	FTA-M09	HA880758	1309757.95	14336954.42	59.1	60.77
68	W	FTA-M10	HA880703	1310698.89	14337201.60	62.8	64.55
69	W	FTA-M11	HA880704	1309956.98	14337975.80	61.8	64.57
70	W	FTA-M12	HA880705	1309415.01	14338042.65	55.1	57.12
71	W	FTA-MD07	HA920386	1310051.60	14337197.02	59.4	60.71
72	W	FTA-MD13	HA920385	1310059.97	14337571.77	60.4	61.71
73	W	FTA-UST	HA881484	1309978.93	14337568.29	60.9	62.49
74	W	G-1	HA881024	1315107.12	14328616.40	31.4	33.51
75	W	HA DF 040	HA811641	1322662.80	14335898.70	29.3	30.93
76	W	HA DF 041	HA811640	1323053.64	14335750.80	29.0	30.65
77	W	HA881481		1320172.25	14338591.05	34.7	36.66
78	W	HA881893		1322282.57	14337620.70	33.7	35.22
79	W	HA920376	HA920376	1333991.18	14338062.38	9.7	9.37
80	W	HA920661	HA920661	1335109.33	14337623.74	5.4	4.86
81	W	HA920662	HA920662	1333404.11	14337866.20	9.1	8.81
82	W	MLF-MW-01		1317695.27	14332513.20	31.0	34.60
83	W	MLF-MW-03		1318527.21	14331971.90	29.0	31.60
84	W	MLF-MW-04		1318463.79	14332117.43	28.2	30.80
85	W	MLF-MW-05		1317976.91	14331744.24	27.8	30.37
86	W	MLF-MW-06		1319056.28	14332590.97	29.8	31.99
87	W	MLF-MW-07		1317438.37	14332155.06	29.9	32.26
88	W	MLF-MW-16		1319101.85	14333247.42	33.8	36.83
89	W	OBA-1		1290421.79	14306842.55	13.0	14.99
90	W	PAAF UST MW-04	HA881831	1311040.73	14336808.80	53.2	52.72
91	W	PAAF UST MW-06	HA881833	1310872.44	14336629.30	53.3	52.54
92	W	PAAF1 (B1040)		1311143.57	14337089.73	58.4	61.90
93	W	PAAF2 (B1041)		1311353.07	14337000.57	55.1	58.34
94	W	PLF-PW-08		1313728.27	14338847.57	61.1	63.69
95	W	PLF-PW-09		1314504.33	14338170.84	36.1	38.39
96	W	PLF-PW-10		1314110.42	14337947.10	33.3	34.54

Sheet 2 of 8 (Surveyed data) Sheet 2 of 13 (Appendix D)

Coordinate Data - Surveyed (Continued)

ROW #	TYPE	NAME	STATE PERMIT NUMBER	UTM, FT (NAD-83) X (EASTING)	UTM, FT (NAD-83) Y (NORTHING)	ELEV., FT (NAVD-88) GROUND SURFACE	ELEV., FT (NAVD-88) TOP PVC RISER
97	W	PLF-PW-11		1314787.22	14338398.85	40.5	43.18
98	W	PLF-PW-12		1315362.31	14338149.40	31.8	34.33
99	W	PLF-PW-13		1316498.06	14338007.91	37.4	39.71
100	W	PLF-PW-16		1315059.84	14339543.14	55.4	57.60
101	W	PLF-PW-17		1315423.09	14339183.46	36.9	39.34
102	W	PLF-PW-18		1316687.67	14337841.24	37.2	38.58
103	W	PLF-PW-19	HA881311	1315317.28	14338768.81	39.3	41.77
104	W	PLF-PW-20	HA881312	1314353.78	14339402.57	52.3	55.03
105	W	PLF-PW-21	HA881313	1315989.41	14339463.78	31.0	33.58
106	W	PLF-PW-22A	HA930292	1314734.26	14340755.92	55.6	55.21
107	W	PLF-PW-22B	HA930293	1314761.39	14340749.91	55.3	55.02
108	W	PLF-PW-23	HA930296	1313898.31	14336179.46	34.9	37.47
109	W	PLF-PW-24	HA930295	1315794.71	14337424.56	31.9	33.88
110	W	PLF-PW-25	HA930539	1313516.00	14340089.00	65.1	66.35
111	W	PLF-PW-26	HA930540	1312637.00	14339645.00	60.3	61.81
112	W	PP-01	HA881009	1311801.25	14327734.35	27.4	26.50
113	W	PP-02	HA881010	1311595.69	14327761.89	28.2	29.33
114	W	PP-03	HA881011	1311636.89	14327949.34	28.7	30.33
115	W	PP-04	HA881012	1311861.30	14328090.05	31.2	30.23
116	W	SP M-1P		1288905.34	14309329.53	15.5	16.87
117	W	SP M-2P		1289680.57	14309835.20	14.6	15.72
118	W	SP W-2		1289716.78	14308888.47	14.1	17.27
119	W	SP W-2A		1289719.71	14308873.12	14.3	16.95
120	W	SP W-4		1289106.69	14309784.04	19.3	23.63
121	W	SP W-4A		1289098.10	14309786.49	20.3	23.34
122	W	SP W-5		1289740.62	14310033.41	28.7	32.70
123	W	SP W-5A		1289765.66	14310024.08	33.9	37.81
124	W	TW2-CB-1		1318329.85	14325766.85	15.2	17.13
125	W	TW2-CB-2		1318700.79	14325401.45	8.4	10.65
126	W	WB-MW-01A	HA920497	1303321.24	14334419.18	44.2	46.34
127	W	WB-MW-01B	HA920496	1303308.02	14334398.31	44.3	46.33
128	W	WB-MW-01C	HA920495	1303274.41	14334343.07	43.7	46.02
129	W	WB-MW-02B	HA920386	1303340.64	14334138.77	42.4	44.31
130	W	WB-MW-02C	HA920387	1303313.01	14334186.83	41.8	43.94
131	W	WB-MW-03A	HA920469	1303307.57	14334002.63	40.8	43.09
132	W	WB-MW-03B	HA920468	1303296.54	14333972.32	40.8	43.01
133	W	WB-MW-03C	HA920467	1303282.15	14333951.93	41.4	43.54
134	W	WB-MW-04A	HA920470	1303227.68	14333812.47	41.4	43.51
135	W	WB-MW-04B	HA920389	1303199.09	14333831.55	41.1	43.38
136	W	WB-MW-04C	HA920388	1303167.44	14333852.79	41.0	43.23
137	W	WB-MW-05A	HA930368	1302208.05	14332620.92	38.9	40.51
138	W	WB-MW-05B	HA930369	1302194.00	14332662.98	38.9	40.15
139	W	WB-MW-05C	HA930370	1302237.12	14332669.69	38.7	40.76
140	W	WB-MW-06A	HA930273	1304111.44	14333639.56	40.8	42.19
141	W	WB-MW-06B	HA930274	1304089.87	14333617.84	41.1	42.79
142	W	WB-MW-06C	HA930275	1304081.82	14333647.25	41.4	43.41
143	W	WB-MW-07A	HA930278	1305294.29	14335616.62	41.7	43.44
144	W	WB-MW-07B	HA930277	1305300.20	14335587.60	40.3	41.88

Sheet 3 of 8 (Surveyed data) Sheet 3 of 13 (Appendix D)

Coordinate Data - Surveyed (Continued)

ROW #	TYPE	NAME	STATE PERMIT NUMBER	UTM, FT (NAD-83) X (EASTING)	Y (NORTHING)	ELEV., FT (NAVD-88) GROUND SURFACE	TOP PVC RISER
145	W	WB-MW-07C	HA930276	1305269.18	14335601.14	41.9	43.83
146	W	WB-MW-08A	HA940387	1305992.51	14332065.45	47.4	49.84
147	W	WB-MW-08B	HA930388	1306007.82	14332041.88	47.3	49.94
148	W	WB-MW-08C	HA930359	1305973.76	14332038.24	46.8	48.33
149	W	WB-MW-09A	HA930371	1305879.68	14333504.74	38.6	40.44
150	W	WB-MW-09B	HA930372	1305890.99	14333477.33	39.9	41.76
151	W	WB-MW-09C	HA930373	1305860.81	14333483.02	38.7	40.53
152	W	WB-MW-10A	HA930281	1306604.76	14335530.35	38.8	40.42
153	W	WB-MW-10B	HA930280	1306568.47	14335497.66	39.3	41.19
154	W	WB-MW-10C	HA930279	1306553.67	14335477.05	39.0	40.99
155	W	WB-MW-11A	HA930284	1308084.62	14335910.36	45.4	46.83
156	W	WB-MW-11B	HA930283	1308104.01	14335891.53	46.0	47.89
157	W	WB-MW-11C	HA930282	1308077.26	14335892.77	45.7	47.53
158	W	WB-MW-12A	HA930271	1307977.44	14337748.07	41.0	42.78
159	W	WB-MW-12B	HA930270	1307961.62	14337757.99	40.9	42.74
160	W	WB-MW-12C	HA930272	1307928.31	14337770.56	40.0	41.91
161	W	WB-MW-13A	HA930374	1310286.88	14338195.85	62.1	63.97
162	W	WB-MW-13B	HA930375	1310258.85	14338185.72	62.3	63.92
163	W	WB-MW-13C	HA960376	1310186.54	14338130.97	60.4	62.68
164	W	WB-MW-14A	HA930286	1308992.73	14333259.70	43.6	45.45
165	W	WB-MW-14B	HA930287	1308974.77	14333274.10	44.1	45.87
166	W	WB-MW-14C	HA930285	1308962.42	14333243.55	44.2	45.80
167	W	WB-MW-15A	HA930377	1308268.17	14331958.22	37.8	39.27
168	W	WB-MW-15B	HA930379	1308250.10	14331934.83	37.6	39.38
169	W	WB-MW-15C	HA930378	1308232.29	14331911.93	37.6	39.36
170	W	WB-MW-16A	HA930703	1301757.00	14326171.00	26.2	28.62
171	W	WB-MW-16B	HA930704	1301747.00	14326200.00	26.1	28.55
172	W	WB-MW-16C	HA930705	1301775.00	14326196.00	25.9	28.08
173	W	WB-MW-17A	HA930706	1299736.66	14327893.51	24.0	26.39
174	W	WB-MW-17B	HA930707	1299723.81	14327864.75	23.6	26.05
175	W	WB-MW-17C	HA930708	1299707.67	14327884.04	24.0	26.44
176	W	WB-MW-18A	HA930709	1297101.91	14324250.36	30.0	32.30
177	W	WB-MW-18B	HA930710	1297098.72	14324220.59	30.6	33.21
178	W	WB-MW-18C	HA930711	1297094.88	14324191.04	34.5	33.90
179	W	WB-MW-19A	HA940358	1302338.50	14333533.24	42.0	43.43
180	W	WB-MW-19B	HA940361	1302335.71	14333563.52	42.0	43.58
181	W	WB-MW-19C	HA930970	1302362.20	14333552.18	41.7	44.18
182	W	WB-MW-20A	HA940386	1302680.19	14333936.62	41.7	41.44
183	W	WB-MW-20B	HA940210	1302699.27	14333922.82	41.6	41.39
184	W	WB-MW-20C	HA940211	1302719.09	14333908.35	41.8	41.49
185	W	WB-MW-21A	HA940385	1301616.74	14333974.52	42.6	42.70
186	W	WB-MW-21B	HA940213	1301589.04	14333987.71	43.0	42.61
187	W	WB-MW-21C	HA940212	1301564.12	14333999.85	43.1	42.34
188	W	WB-MW-22A	HA940383	1302173.50	14335324.89	38.2	37.92
189	W	WB-MW-22B	HA940384	1302155.31	14335299.36	38.0	37.69
190	W	WB-MW-22C	HA940360	1302141.08	14335277.90	38.2	38.07
191	W	WES-MW-01	HA814397	1317659.66	14332798.97	32.2	34.61
192	W	WES-MW-02	HA814398	1318146.08	14333179.11	33.8	36.43

Sheet 4 of 8 (Surveyed data) Sheet 4 of 13 (Appendix D)

Coordinate Data - Surveyed (Continued)							
ROW #	TYPE	NAME	STATE PERMIT NUMBER	UTM, FT (NAD-83) X (EASTING)	Y (NORTHING)	ELEV., FT (NAVD-88) GROUND SURFACE	TOP PVC RISER
193	W	WES-MW-03	HA814399	1318155.89	14333161.58	33.8	36.35
194	W	WES-MW-04	HA814400	1318166.02	14333143.98	33.9	36.45
195	W	WES-MW-05	HA814401	1318526.41	14333526.68	35.3	37.77
196	W	WES-MW-06	HA814402	1318534.21	14333507.90	34.7	37.15
197	W	WES-MW-07	HA814403	1318541.90	14333489.18	34.5	37.01
198	W	WES-MW-08	HA814404	1317612.39	14332243.83	33.7	36.02
199	W	WES-MW-09	HA814405	1317634.78	14331842.96	28.2	26.35
200	W	WES-MW-10	HA814406	1317990.68	14331862.05	27.1	28.51
201	W	WES-MW-11	HA814407	1318002.73	14331847.01	27.3	28.85
202	W	WES-MW-12	HA814408	1318014.66	14331831.77	27.5	28.95
203	W	WES-MW-13	HA814409	1318186.04	14332006.80	27.2	28.78
204	W	WES-MW-14	HA814410	1318542.75	14332185.41	27.9	29.38
205	W	WES-MW-15	HA814411	1318553.61	14332168.93	28.8	30.42
206	W	WES-MW-16	HA814412	1318562.88	14332152.44	28.5	30.61
207	W	WES-MW-17	HA814413	1318804.35	14332357.62	28.8	30.42
208	W	WES-MW-18	HA814414	1319123.96	14332665.83	30.5	32.04
209	W	WES-MW-19	HA814415	1319110.63	14332650.25	30.2	31.73
210	W	WES-MW-20	HA814416	1319097.58	14332635.46	30.1	31.57
211	W	WES-MW-21	HA814417	1319013.45	14332968.50	33.9	35.54
212	W	WES-MW-22	HA814669	1318947.03	14332219.51	29.3	30.81
213	W	WES-MW-23	HA814670	1318959.64	14332204.92	29.5	30.86
214	W	WES-MW-24	HA814671	1318442.16	14331638.75	30.6	32.16
215	W	WES-MW-25	HA814672	1318457.68	14331627.84	30.8	32.17
216	W	WES-MW-26	HA930575	1318017.65	14334081.43	36.7	38.64
217	W	WES-MW-27	HA930576	1318040.40	14334076.71	36.6	38.57
218	W	WES-MW-28	HA930577	1318017.91	14334049.62	36.1	38.46
219	W	WES-MW-29	HA930578	1317094.37	14331950.39	26.4	28.49
220	W	WES-MW-30	HA930579	1317095.45	14331925.49	26.3	28.51
221	W	WES-MW-31	HA930580	1317095.41	14331901.15	26.4	28.36
222	W	WES-MW-32	HA930581	1317989.16	14331159.97	31.1	33.20
223	W	WES-MW-33	HA930582	1318015.33	14331133.48	31.1	33.03
224	W	WES-MW-34	HA930583	1318013.27	14331111.39	31.0	32.95
225	W	WES-MW-35	HA930585	1319320.74	14331500.41		31.37
226	W	WES-MW-36	HA930584	1319338.17	14331479.80		31.21
227	W	WES-MW-37	HA930583	1319371.33	14331474.46		31.20
228	W	WES-MW-38	HA930587	1320298.98	14333728.14	34.5	36.31
229	W	WES-MW-39	HA930574	1320314.55	14333710.58	35.2	36.88
230	W	WES-MW-40	HA930573	1320335.84	14333688.60	35.8	37.82
231	W	WES-MW-41	HA930572	1319318.79	14333959.35	36.2	38.43
232	W	WES-MW-42	HA930570	1319318.82	14333934.23	36.2	38.72
233	W	WES-MW-43	HA930571	1319326.77	14333909.43	36.3	38.77
234	W	WOODREST CR.		1326939.64	14332792.52	12.4	14.46
235	W	X-1		1323934.67	14336791.08		11.24
236	W	X-2		1323866.16	14336387.61		17.29
237	P	FTA-P01	HA920349	1308268.78	14340062.78	49.8	51.54
238	P	FTA-P02	HA920348	1309761.97	14339582.23	41.9	43.61
239	P	FTA-P03	HA920347	1307023.48	14338136.71	42.3	44.24
240	P	FTA-P04	HA920350	1307673.79	14337871.90	37.4	38.99

Sheet 5 of 8 (Surveyed data) Sheet 5 of 13 (Appendix D)

Coordinate Data - Surveyed (Continued)

ROW #	TYPE	NAME	STATE PERMIT NUMBER	UTM, FT (NAD-83) X (EASTING)	UTM, FT (NAD-83) Y (NORTHING)	ELEV., FT (NAVD-88) GROUND SURFACE	ELEV., FT (NAVD-88) TOP PVC RISER
241	P	FTA-P05	HA920351	1311856.42	14337899.16	51.2	53.02
242	P	FTA-P06	HA920352	1307637.09	14336893.97	40.6	42.37
243	P	FTA-P07	HA920353	1308785.99	14336722.27	52.2	54.02
244	P	FTA-P08	HA920354	1305277.98	14335149.19	43.1	44.64
245	P	FTA-P09	HA920355	1307426.04	14335282.50	40.9	42.76
246	P	FTA-P10	HA920356	1310205.03	14336234.23	60.9	58.96
247	P	FTA-P11	HA920357	1308523.25	14334667.22	49.7	51.61
248	P	FTA-P12	HA920358	1306679.48	14334004.15	41.6	43.17
249	P	FTA-P13	HA920316	1312007.25	14334508.53	30.7	32.57
250	P	FTA-P14	HA920317	1303491.54	14332197.83	32.7	34.36
251	P	FTA-P15	HA920318	1305310.04	14332713.60	32.8	34.26
252	P	FTA-P16	HA920319	1306003.80	14333011.17	40.7	42.25
253	P	FTA-P17	HA920320	1309019.87	14333226.76	43.2	44.79
254	P	PLP-01	HA930039	1312807.71	14340751.92	68.7	70.85
255	P	PLP-02	HA930040	1313593.15	14340886.20	63.6	65.90
256	P	PLP-03	HA930041	1313854.33	14341338.52	58.1	60.40
257	P	PLP-04	HA930042	1312613.54	14339074.55	62.3	64.46
258	P	PLP-05	HA930043	1312739.95	14337342.43	38.4	38.02
259	P	PLP-06	HA930044	1315995.64	14340478.04	59.5	61.84
260	P	PLP-07	HA930045	1315732.22	14341638.92	63.9	66.25
261	P	PLP-08	HA930046	1315568.57	14342517.60	60.3	62.93
262	P	PLP-09	HA930047	1315827.58	14343263.23	66.3	68.69
263	P	PLP-10	HA930048	1316553.41	14343966.65	63.3	64.90
264	P	PLP-11	HA930294	1316604.19	14342266.16	58.3	60.66
265	P	PLP-12	HA930049	1317854.27	14341048.38	61.0	63.53
266	P	PLP-13	HA930050	1312211.49	14343608.95	52.7	55.25
267	P	PLP-14	HA930051	1311206.08	14340591.76	57.1	59.31
268	P	PLP-15	HA930052	1309444.04	14341726.50	69.0	71.32
269	P	PLP-16		1316159.70	14336945.60	32.0	34.37
270	P	PLP-17	HA930765	1311517.29	14342313.78	45.9	47.42
271	P	PLP-18		1311178.00	14344052.00	50.0	52.52
272	P	PLP-19	HA930767	1312190.36	14344942.11	62.3	63.56
273	P	PLP-20	HA930768	1312126.04	14342512.63	48.6	50.03
274	P	PLP-21	HA930769	1312319.46	14343876.98	55.7	57.42
275	P	PLP-22	HA930770	1313440.58	14342767.04	68.3	69.74
276	P	PLP-23	HA930771	1314165.77	14344121.50	63.9	65.61
277	P	PLP-24	HA930772	1313644.42	14344878.72	62.0	63.27
278	P	PLP-25	HA930971	1312023.26	14345752.92	62.9	63.38
279	P	WB-P-01	HA920494	1304726.22	14334677.76	39.7	42.46
280	P	WB-P-02	HA920493	1304597.37	14334055.80	41.4	43.80
281	P	WB-P-03	HA920492	1304019.56	14333072.65	40.3	42.92
282	P	WB-P-04	HA920473	1303863.34	14333700.34	43.1	45.52
283	P	WB-P-05	HA920490	1303207.07	14333150.64	38.9	41.50
284	P	WB-P-06	HA920491	1302916.45	14332602.31	36.8	39.08
285	P	WB-P-07	HA920471	1304024.03	14335571.19	46.6	48.54
286	P	WB-P-08	HA920472	1302630.64	14333310.79	39.7	42.48
287	P	WB-P-09	HA920498	1302196.53	14332593.41	39.6	41.95
288	P	WB-P-10A	HA930763	1306382.81	14337420.72	39.7	42.15

Sheet 6 of 8 (Surveyed data) Sheet 6 of 13 (Appendix D)

Coordinate Data - Surveyed (Continued)

ROW #	TYPE	NAME	STATE PERMIT NUMBER	UTM, FT (NAD-83) X (EASTING)	UTM, FT (NAD-83) Y (NORTHING)	ELEV., FT (NAVD-88) GROUND SURFACE	ELEV., FT (NAVD-88) TOP PVC RISER
289	P	WB-P-10B	HA930962	1306366.30	14337394.76	40.3	42.76
290	P	WB-P-11A	HA930712	1314137.66	14329614.34	26.4	28.48
291	P	WB-P-11B	HA930713	1314169.02	14329603.05	26.3	28.37
292	P	WB-P-12A	HA930714	1309149.32	14330313.44	26.1	28.30
293	P	WB-P-12B	HA930715	1309146.41	14330272.98	26.5	28.64
294	P	WB-P-13A	HA930716	1309891.53	14325709.30	28.1	30.23
295	P	WB-P-13B	HA930717	1309878.40	14325675.07	28.1	29.68
296	P	WB-P-14A	HA930720	1305289.12	14329097.60	43.3	45.09
297	P	WB-P-14B	HA930721	1305254.50	14329102.72	44.0	47.05
298	P	WB-P-15A	HA940018	1307557.42	14322816.88	20.4	21.79
299	P	WB-P-15B	HA930963	1307585.64	14322792.32	20.4	22.19
300	P	WB-P-16A	HA930718	1305373.57	14324136.89	25.8	28.24
301	P	WB-P-16B	HA930719	1305364.15	14324106.31	25.4	27.73
302	P	WB-P-17A	HA940017	1304871.66	14319609.96	19.2	21.39
303	P	WB-P-17B	HA930964	1304906.86	14319601.03	20.6	22.34
304	P	WB-P-18A	HA930709	1301519.49	14322383.51	23.1	25.82
305	P	WB-P-18B	HA930965	1301489.35	14322394.19	24.0	26.28
306	P	WB-P-19A	HA940498	1299147.65	14322012.48	35.5	37.97
307	P	WB-P-19B	HA930966	1299167.29	14322029.81	36.4	38.83
308	P	WB-P-20A	HA940016	1300320.11	14315956.72	13.3	14.67
309	P	WB-P-20B	HA930967	1300306.28	14315939.45	12.9	14.61
310	P	WB-P-21A	HA940389	1295045.64	14317856.16	13.6	16.11
311	P	WB-P-21B	HA930968	1295012.96	14317854.75	13.3	15.31
312	P	WB-P-22A		1301849.68	14333304.98	36.2	37.57
313	P	WB-P-22B	HA930969	1301820.87	14333298.37	36.0	38.11
314	P	WES-PZD-6	HA940038	1318827.53	14336823.32	30.0	32.60
315	P	WES-PZD-7	HA940040	1314955.12	14333366.22	29.1	31.43
316	P	WES-PZD-8	HA940485	1313527.24	14334582.76	35.1	37.87
317	P	WES-PZS-1	HA930569	1316644.75	14334652.91	30.7	32.48
318	P	WES-PZS-2	HA930568	1317134.11	14330524.87	22.4	24.30
319	P	WES-PZS-3	HA930567	1317059.38	14333082.10	35.5	37.85
320	P	WES-PZS-4	HA930566	1316310.83	14332804.03	31.3	33.44
321	P	WES-PZS-5	HA930565	1319715.74	14332949.21	30.7	33.07
322	P	WES-PZS-6	HA940037	1318809.70	14336798.72	29.8	32.50
323	P	WES-PZS-7	HA940039	1314967.76	14333397.25	28.4	30.82
324	P	WES-PZS-8	HA940484	1313541.52	14334609.53	34.9	37.37
325	B	MLF B08		1318040.00	14334040.00	35.6	
326	B	MLF B09		1317110.00	14331895.00	25.8	
327	B	MLF B10		1318052.00	14331136.00	31.5	
328	B	MLF B11		1319368.00	14331425.00	30.9	
329	B	MLF B12		1320357.00	14333667.00	35.1	
330	B	MLF B13		1319336.00	14333888.00	35.7	
331	B	PLF SB01		1311906.00	14337932.00	48.9	
332	B	PLF SB02		1314415.00	14339473.00	56.1	
333	B	PLF SB03		1314786.00	14340741.00	55.6	
334	B	PLF SB04		1313865.00	14336168.00	35.3	
335	B	PLF SB05		1315402.00	14338117.00	30.4	
336	B	PLF SB06		1316027.00	14339536.00	31.7	

Sheet 7 of 8 (Surveyed data) Sheet 7 of 13 (Appendix D)

Coordinate Data - Surveyed (Concluded)							
ROW #	TYPE	NAME	STATE PERMIT NUMBER	UTM, FT (NAD-83) X (EASTING)	Y (NORTHING)	ELEV., FT (NAVD-88) GROUND SURFACE	TOP PVC RISER
337	B	PLF SB07		1316159.70	14336945.60	32.6	
338	B	WB-PB-05		1302260.05	14332690.77	37.9	
339	B	WB-PB-06		1304058.18	14333650.54	41.7	
340	B	WB-PB-07		1305236.58	14335587.16	41.4	
341	B	WB-PB-08		1305942.19	14332040.69	46.3	
342	B	WB-PB-09		1305817.45	14333471.42	36.4	
343	B	WB-PB-10		1306561.63	14335456.73	37.7	
344	B	WB-PB-11		1308063.19	14335857.20	46.3	
345	B	WB-PB-12		1307714.44	14337893.73	32.7	
346	B	WB-PB-13		1310168.37	14338112.63	58.6	
347	B	WB-PB-14		1308942.78	14333219.69	43.9	
348	B	WB-PB-15		1308213.05	14331886.92	37.2	
349	B	WB-PB-16		1301840.22	14326135.25	25.4	
350	B	WB-PB-17		1299694.30	14327850.75	24.9	
351	B	WB-PB-18		1297088.25	14324160.96	31.4	
352	B	WB-PB-19		1302388.91	14333530.84	40.9	
353	B	WB-PB-20		1302685.62	14333904.07	41.5	
354	B	WB-PB-21		1301610.06	14334008.25	42.7	
355	B	WB-PB-22		1302116.70	14335295.39	37.5	
356	B	WB-SB-01		1306540.21	14337330.78	30.8	
357	B	WB-SB-02		1303294.91	14334165.30	41.5	
358	B	WB-SB-03		1303115.68	14333870.90	40.2	
359	B	WB-SB-04		1308499.36	14334656.31	49.0	
360	B	WB-SB-12		1307091.96	14332880.96	51.9	
361	B	WB-SB-13		1301840.22	14326135.25	25.4	
362	B	WB-SB-14		1300277.16	14315923.31	12.2	
363	B	WB-SB-15		1307536.89	14328886.89	41.5	

NOTE: The "TYPE" colume indicates:
W – Well
P – Piezometer
B – Boring

Sheet 8 of 8 (Surveyed data) Sheet 8 of 13 (Appendix D)

Coordinate Data - Digitized				
ROW #	NAME	DIGITIZED UTM, FT		ESTIMATED GROUND SURFACE, FT
		DIGITIZED X (EASTING)	DIGITIZED Y (NORTHING)	
1	1-69	1308221	14341155	55
2	1-70	1305821	14338097	
3	2-68	1303548	14334860	46
4	2-69	1308739	14343102	68
5	3-69	1307750	14340252	46
6	3-70	1304004	14335538	
7	4-68	1305785	14338139	
8	4-69	1303974	14335563	47
9	5-70	1302708	14333442	41
10	7-70	1309781	14342787	
11	B 0340 B	1326524	14337070	34
12	B 0340 C	1326550	14337010	32
13	B 04	1326927	14332776	
14	B 0525 B01	1328385	14332038	
15	B 0525 B02	1328324	14331878	
16	B 0525 B03	1328243	14331882	
17	B 0525 B04	1328262	14331812	
18	B 0525 B05	1328113	14331664	
19	B 1047 B12	1310946	14336832	
20	B 1047 B13	1310972	14336784	
21	B 1047 B14	1310961	14336708	
22	B 1047 B15	1310903	14336735	
23	B 1047 B16	1310903	14336735	
24	B 1047 MW04	1311041	14336809	53
25	B 1047 MW05	1310965	14336654	
26	B 1047 MW06	1310872	14336629	53
27	B 1047 MW07	1310848	14336741	
28	B 1047 MW08	1310866	14336894	
29	B 1047 MW09	1310776	14336639	
30	B 1047 MW10	1310849	14336799	
31	B 1047 MW11	1310794	14337020	
32	B 1053	1305589	14332809	
33	B 2515 CG01	1319703	14344627	
34	B 2831 A	1316217	14346703	
35	B 2831 C	1316223	14346712	
36	B 3011 MW01	1323180	14338359	
37	B 3011 MW02	1323174	14338341	
38	B 3011 MW03	1323185	14338330	
39	B 3070A MW02	1322081	14338235	
40	B 3070A MW03	1322056	14338222	
41	B 4001	1322441	14337478	
42	B 4020 MW03	1322155	14337362	38
43	B 4020 MW04	1321881	14337590	34
44	B 4020 MW08	1321807	14337653	
45	B 4020 MW09	1321922	14337563	
46	B 4020 MW11	1321735	14337710	
47	B 4020 MWX	1321951	14337528	
48	B 4021 A	1321443	14337935	

Sheet 1 of 5 (Digitized data) Sheet 9 of 13 (Appendix D)

Coordinate Data - Digitized (Continued)				
ROW #	NAME	DIGITIZED UTM, FT DIGITIZED X (EASTING)	DIGITIZED UTM, FT DIGITIZED Y (NORTHING)	ESTIMATED GROUND SURFACE, FT
49	B 4021 C	1321550	14337845	
50	B 4021 D	1321601	14337811	
51	B 4021 MW02	1321404	14337961	
52	B 4021 MW04	1321520	14337875	
53	B 4025	1321824	14337918	
54	B 4027 B05	1322081	14337773	
55	B 4027 B09	1322119	14337743	
56	B 4027 MW02	1322158	14337725	
57	B 4027 MW04	1322197	14337760	
58	B 4027 MW06	1322175	14337751	
59	B 4029	1322419	14337760	
60	B 4119 MW01	1321109	14338723	
61	B 4119 MW02	1321087	14338693	
62	B 4119 MW03	1321062	14338663	
63	B 4201 (HA 881780)	1321340	14337944	34
64	B 5042	1320813	14337768	
65	B 5043 MW01	1320711	14337614	
66	B 5043 MW02	1320741	14337593	
67	B 5043 MW03	1320762	14337576	
68	B 5051 MW01	1319654	14337701	
69	B 5051 MW02	1319632	14337685	
70	B 5051 MW03	1319619	14337666	
71	B 5051 MW04	1319635	14337656	
72	B 5206 MW01	1319623	14338984	
73	B 5206 MW02	1319666	14338972	
74	B 5206 MW03	1319674	14338929	
75	B 5413 MW01	1318043	14339541	
76	B 5413 MW02	1318039	14339494	
77	B 5413 MW03	1318026	14339447	
78	B 5454 MW01	1317263	14338937	
79	B 5454 MW02	1317298	14338942	
80	B 5454 MW03	1317315	14338912	
81	B3-CB-1	1319680	14327350	34
82	BRIAR B01	1297412	14303074	
83	BRIAR B02	1297427	14303234	
84	BRIAR B03	1297407	14302898	
85	CAP 01	1311315	14346878	65
86	CAP 02	1311214	14346421	65
87	CAP 04	1311142	14346157	55
88	CAP 07	1314512	14342873	68
89	CAP 08	1315072	14343572	68
90	CAP 09	1315429	14344062	83
91	CAP 10	1315132	14344744	
92	DM BOR101	1296489	14327921	25
93	DM BOR102	1291573	14324095	20
94	DM BOR103	1293792	14325009	
95	DM BOR104	1295231	14325222	42
96	DM BOR105	1294479	14323756	23
Sheet 2 of 5 (Digitized data)			Sheet 10 of 13 (Appendix D)	

Coordinate Data - Digitized (Continued)

ROW #	NAME	DIGITIZED UTM, FT		ESTIMATED GROUND SURFACE, FT
		DIGITIZED X (EASTING)	DIGITIZED Y (NORTHING)	
97	DM BOR105A	1294180	14323626	
98	DM BOR106	1292828	14322411	
99	DM BOR107	1296542	14324143	34
100	DM BOR108	1293352	14321699	
101	DM BOR109	1296201	14322422	
102	DM BOR110	1294102	14321607	9
103	DM BOR111	1291403	14322602	1
104	DM BOR112	1292419	14321594	1
105	DM BOR113	1293521	14320726	1
106	DM BOR114	1292965	14321207	
107	DM BOR115	1292137	14322244	
108	DM BOR116	1291802	14323197	
109	DM BOR117	1290870	14323322	
110	DM BOR118	1290943	14323805	1
111	DM BOR119	1290376	14324344	1
112	DM BOR120	1291404	14322306	
113	FTA B01	1309866	14337371	
114	FTA B02	1309788	14337841	
115	FTA B03	1310288	14337759	
116	GM 01	1295665	14327342	
117	GM 02	1295539	14327304	
118	GM 03	1294877	14326652	
119	GM 04	1294916	14326876	
120	GM 05	1294430	14325368	
121	GM 06	1294303	14325388	
122	GM 07	1292728	14325329	
123	GM 08	1292786	14325183	
124	GM 09	1297571	14326953	
125	GM 10	1296219	14325991	
126	GM 11	1293603	14325757	
127	GM 12	1291823	14324755	
128	GM 13	1298476	14330348	
129	GM 14	1298388	14330270	
130	GM 15	1299876	14331933	
131	GM 16	1299750	14331787	
132	HA 700086	1301467	14334562	
133	HA 720433	1305576	14332795	
134	HA 735410 (B 1135)	1340611	14327805	
135	HA 810061 (B 899)	1301080	14325952	
136	HA 810062 (B 1191)	1338248	14334214	
137	HA 810063 (B 1163)	1333330	14332100	
138	HA 810978	1299911	14330645	
139	HA 813093 (B 1197A)	1334145	14333190	
140	HA 920161	1303915	14339488	
141	HA DE 028	1301582	14335968	40
142	HA DE 060	1297602	14325276	28
143	HA DE 063	1306051	14338316	35
144	HA DE 070	1303257	14334555	45

Sheet 3 of 5 (Digitized data) Sheet 11 of 13 (Appendix D)

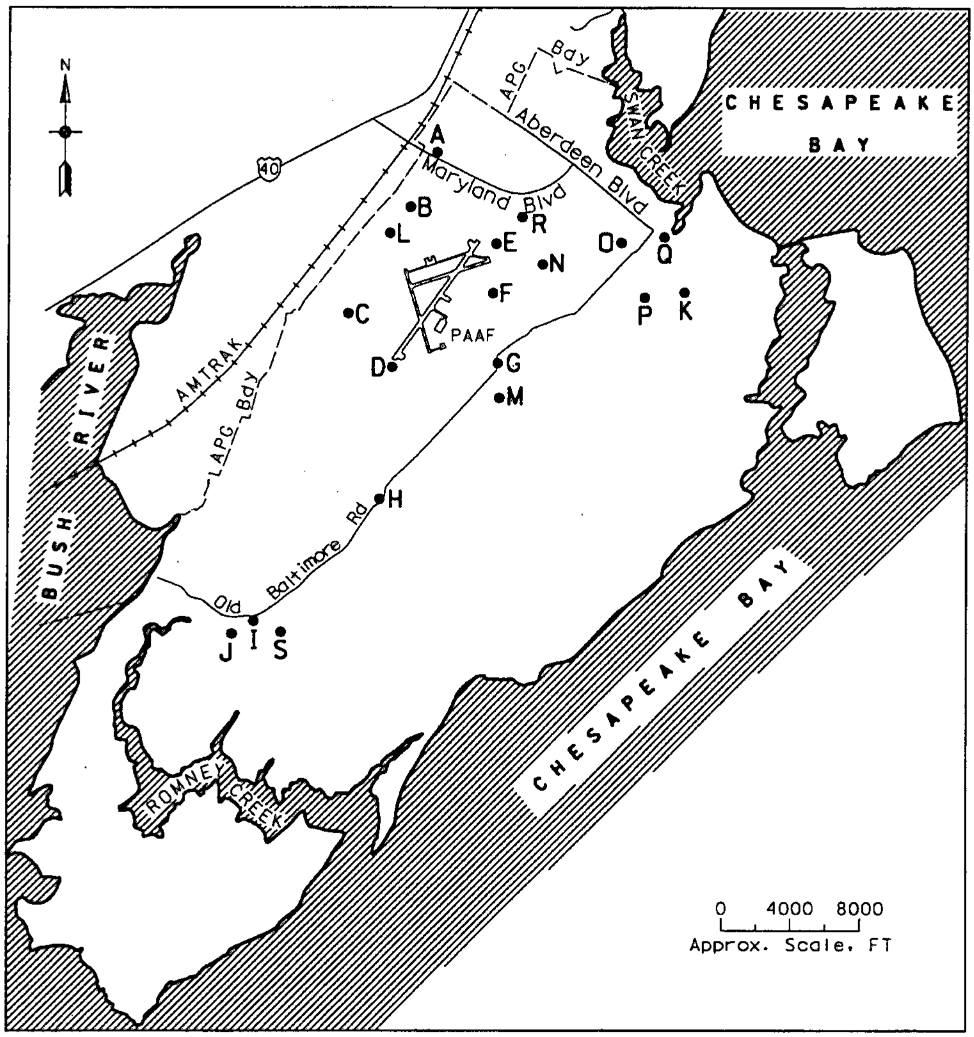
Coordinate Data - Digitized (Continued)				
ROW #	NAME	DIGITIZED UTM, FT		ESTIMATED GROUND SURFACE, FT
		DIGITIZED X (EASTING)	DIGITIZED Y (NORTHING)	
145	HA DE 072	1299888	14336436	40
146	HA DE 074	1300173	14336314	40
147	HA DE 080	1300547	14340581	65
148	HA DE 085	1296309	14320381	15
149	HA DE 085	1296175	14320570	15
150	HA DE 117	1302383	14336811	30
151	HA DE 141	1294821	14326962	25
152	HA DE 142	1294285	14328161	14
153	HA DE 150	1293221	14330667	23
154	HA DE 153	1292686	14325199	25
155	HA DE 164	1294707	14332672	60
156	HA DE 165	1290699	14325261	20
157	HA DE 166	1292597	14328584	20
158	HA DE 169	1305531	14342651	60
159	HA DE 195	1306687	14341849	
160	HA DE 197-199	1296459	14336947	20
161	HA DE 211	1296182	14320571	15
162	HA DE 224	1294676	14326160	25
163	HA DE 225	1294676	14326160	25
164	HA DF 40	1322663	14335899	32
165	HA DF 41	1323054	14335751	29
166	HA DG 03	1336928	14326396	12
167	HCP 01	1299736	14336535	40
168	HCP 02	1299653	14336233	40
169	HCP 03	1300757	14334907	50
170	HCP 04	1301467	14334555	45
171	HCP 05	1302990	14334139	40
172	HCP 06	1302854	14333744	40
173	HCP 08	1304806	14336880	46
174	HCP 09	1305817	14338112	46
175	MGS 07A	1306416	14342231	
176	MLF B01	1317292	14332349	
177	MLF B02	1318117	14332754	
178	MLF B03	1318796	14332573	
179	MLF B04	1318551	14332156	
180	MLF B05	1318222	14331983	
181	MLF B08	1318040	14334040	
182	MLF MW02	1318445	14332951	
183	MULBERRY DOCK DH01	1329977	14327037	
184	MULBERRY DOCK DH02	1330005	14327012	
185	MULBERRY DOCK DH03	1330029	14326991	
186	P-1 (HA DF 07)	1324275	14337236	
187	P-2 (HA DF 09)	1324011	14336827	
188	P-3 (HA DF 10)	1323920	14336462	
189	P-4 (HA DF 11)	1323641	14336225	
190	P-5 (HA DF 08)	1323641	14336010	
191	PIER 01	1307137	14343933	65
192	PM 01D	1296883	14330323	
Sheet 4 of 5 (Digitized data)				Sheet 12 of 13 (Appendix D)

Coordinate Data - Digitized (Concluded)				
ROW #	NAME	DIGITIZED UTM, FT		ESTIMATED GROUND SURFACE, FT
		DIGITIZED X (EASTING)	DIGITIZED Y (NORTHING)	
193	PM 02D	1297116	14327785	
194	PM 03D	1295159	14323097	
195	PM 04D	1298762	14327107	
196	PM 05D	1294074	14328424	
197	PROD (B 1135)	1340594	14327800	
198	PROD (B 1138)	1337986	14330238	
199	PROD (B 1141)	1338941	14330878	
200	PROD (B 1146)	1339483	14328911	
201	PROD (B 1163)	1333307	14332083	
202	PROD (B 1171)	1338295	14335419	
203	PROD (B 1188)	1338614	14333268	
204	PROD (B 1191)	1338248	14334134	
205	PROD (B 1196)	1339790	14328192	
206	PROD (B 1199)	1339267	14332529	
207	PROD (B 1199)ABD	1339307	14332316	
208	PW 14	1314061	14339260	
209	PW 15	1314744	14338651	
210	SCB 01	1324955	14338259	
211	SCB 02	1324827	14338362	
212	SCB 03	1325042	14338573	
213	SITE 01	1314477	14342870	
214	SITE 02	1315071	14343569	
215	SITE 03	1315428	14344014	
216	SITE 04	1315769	14344401	
217	SITE 05	1315145	14344742	
218	SP B01	1289163	14309533	
219	SP B02	1289618	14310350	
220	SP C01	1289281	14309942	
221	SP C02	1288824	14309486	
222	SP C03	1288381	14309251	
223	SP W03	1288946	14308895	
224	T-1 (HA 810244)	1302082	14314734	10
225	T-2	1312777	14317546	12
226	T-3	1319611	14327435	25
227	T-4	1316179	14323209	10
228	TW 12	1324081	14339370	
229	TW 13	1324355	14338784	
230	TW 15	1322232	14341267	
231	TW 17	1317014	14343207	
232	TW 19	1312278	14339513	
233	TW 20	1310551	14337656	60
234	TW 21	1320899	14337709	
235	TW 22	1315057	14341939	
236	WCB 01	1327201	14332257	
237	WCB 03	1327174	14332508	
238	WELL 120	1325646	14337472	25
Sheet 5 of 5 (Digitized data)			Sheet 13 of 13 (Appendix D)	

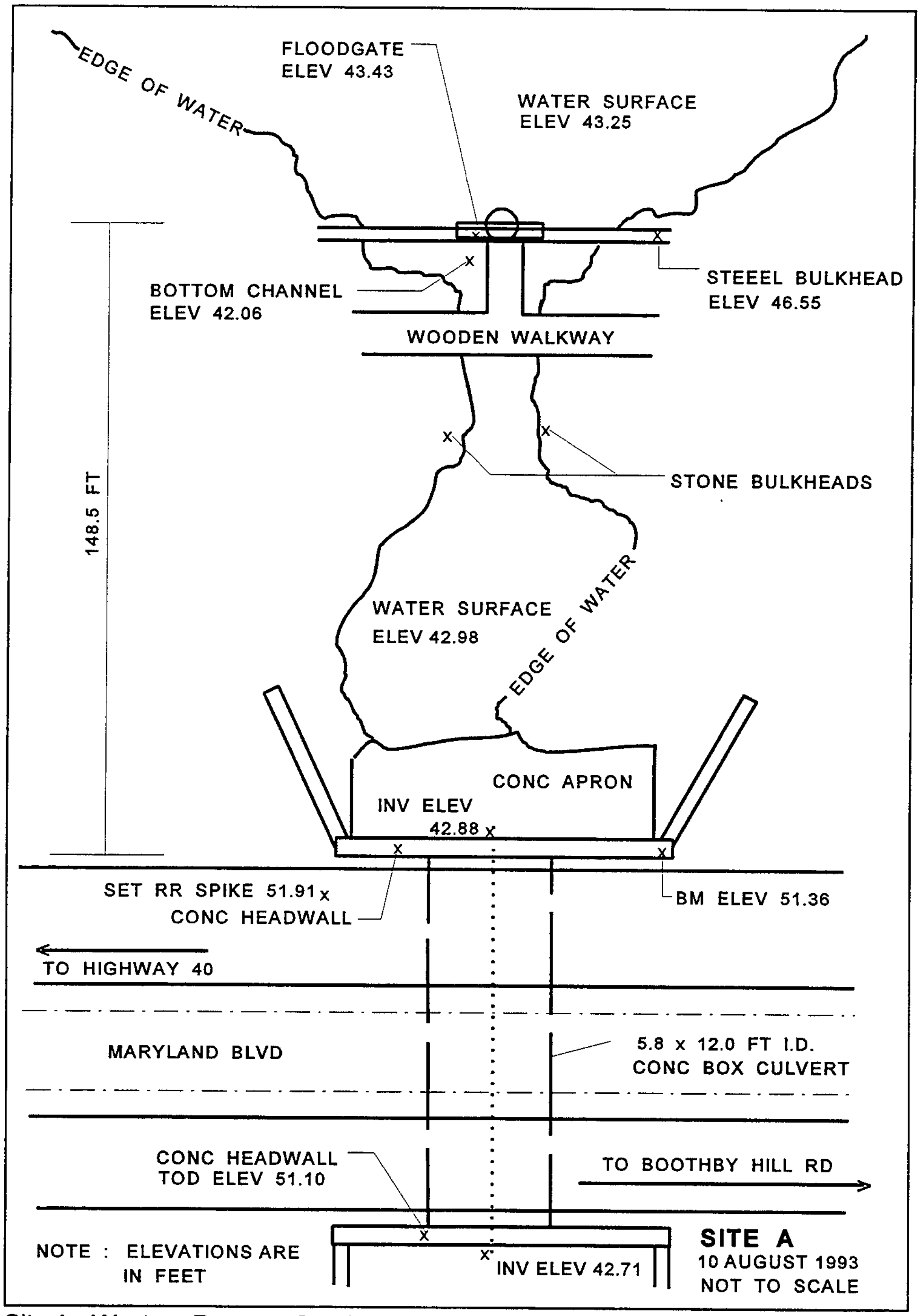
Appendix E

Location of Survey Points for Surface Water and Streambed Elevations

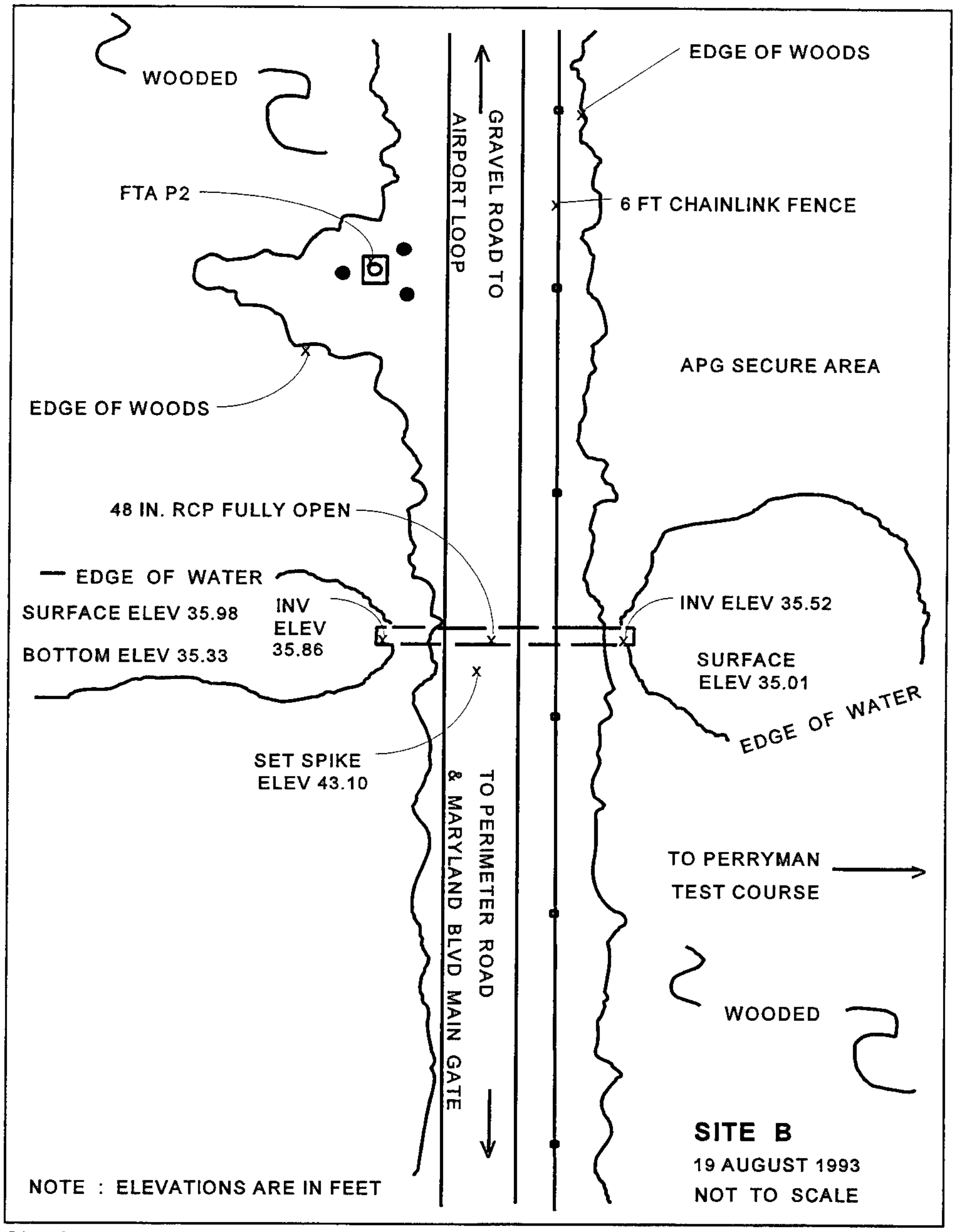
Aberdeen Proving Ground-Aberdeen Area, Maryland



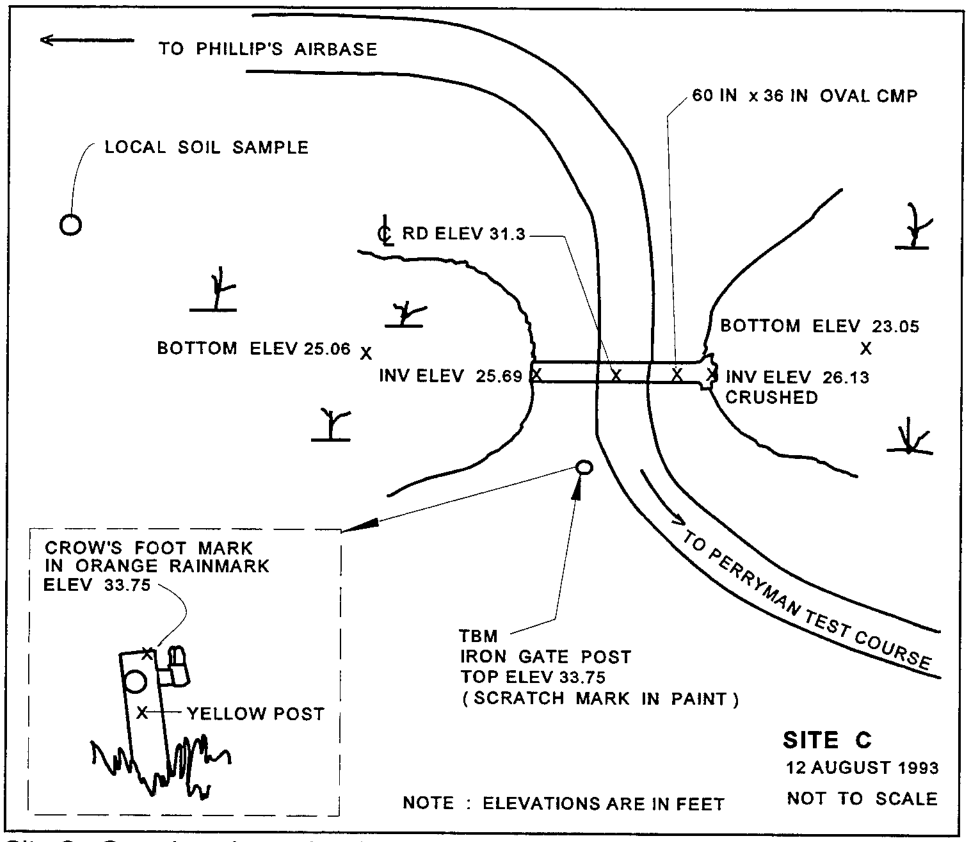
Location of survey points for surface water and streambed elevations on APG-AA



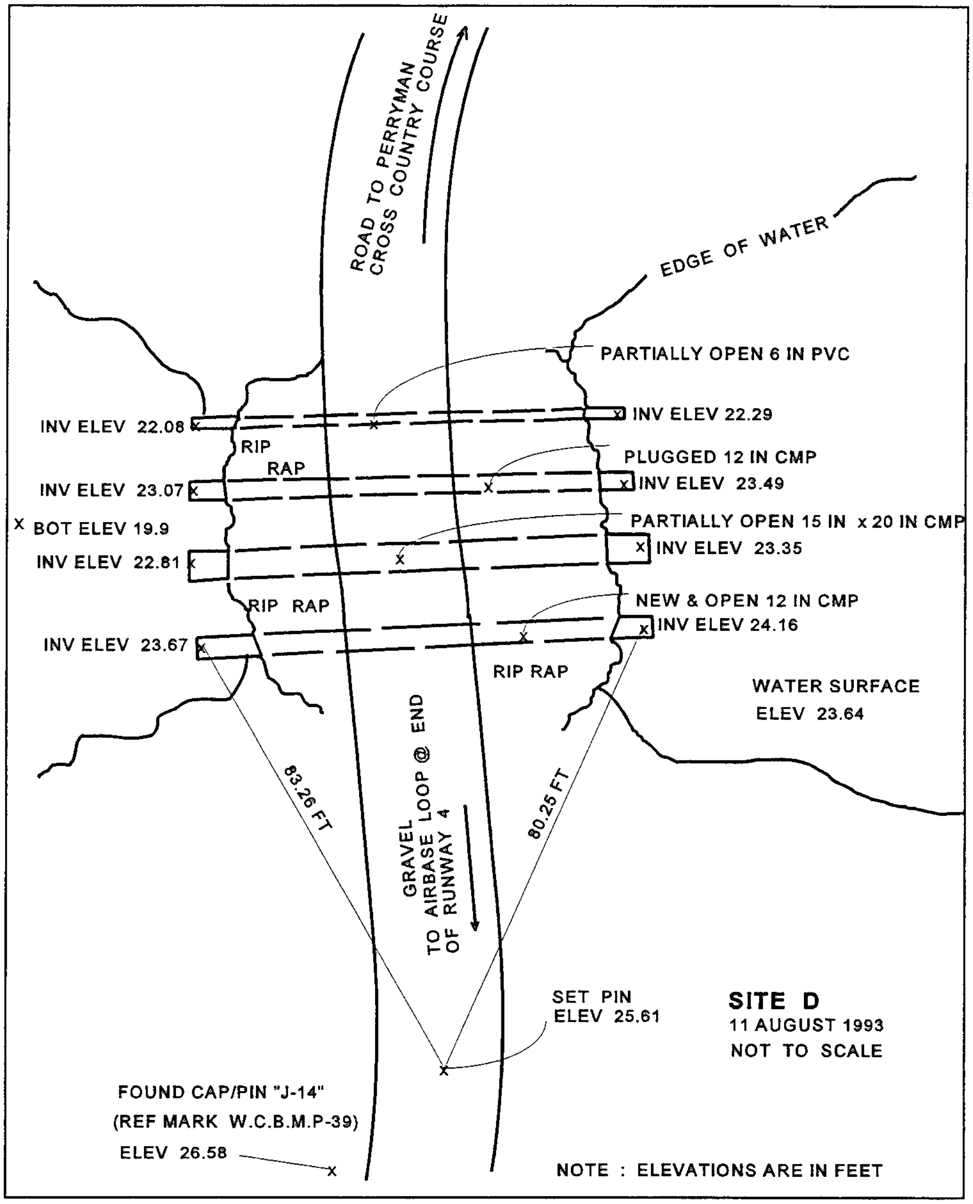
Site A. Western Romney Creek tributary weir control structure north of Maryland Boulevard approximately 50 yd



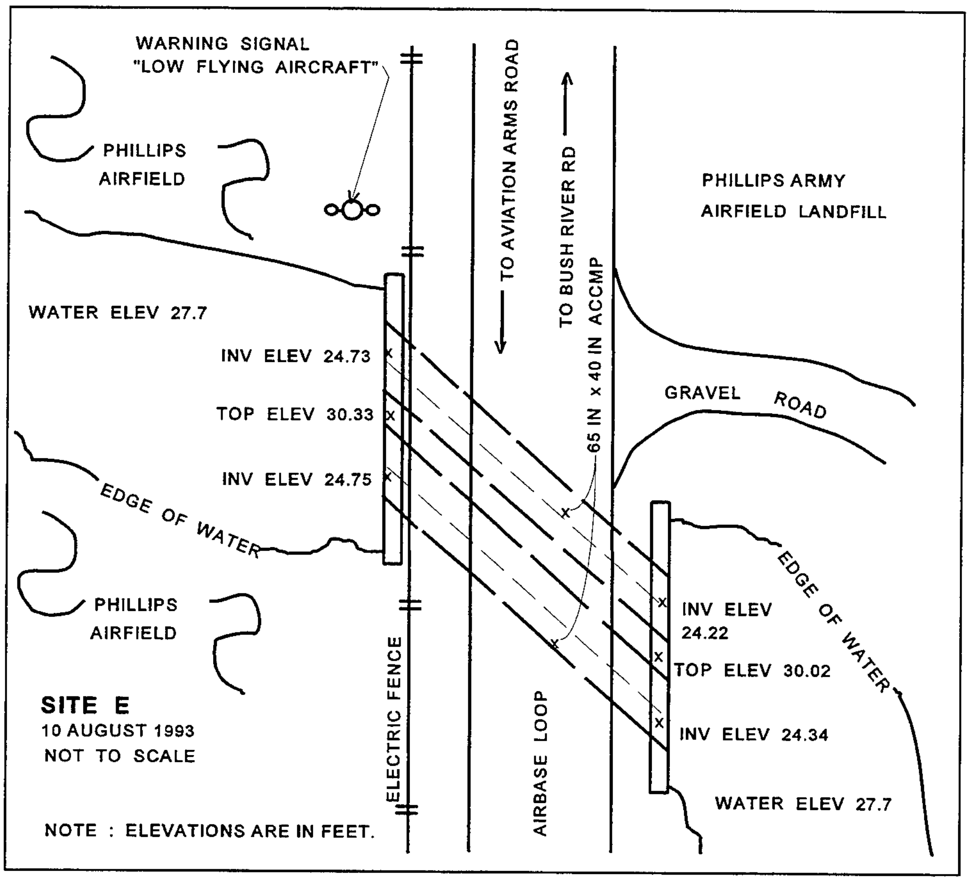
Site B. Gravel road crossing the western tributary of Romney Creek between the restricted area fence and Ruggles Golf Course



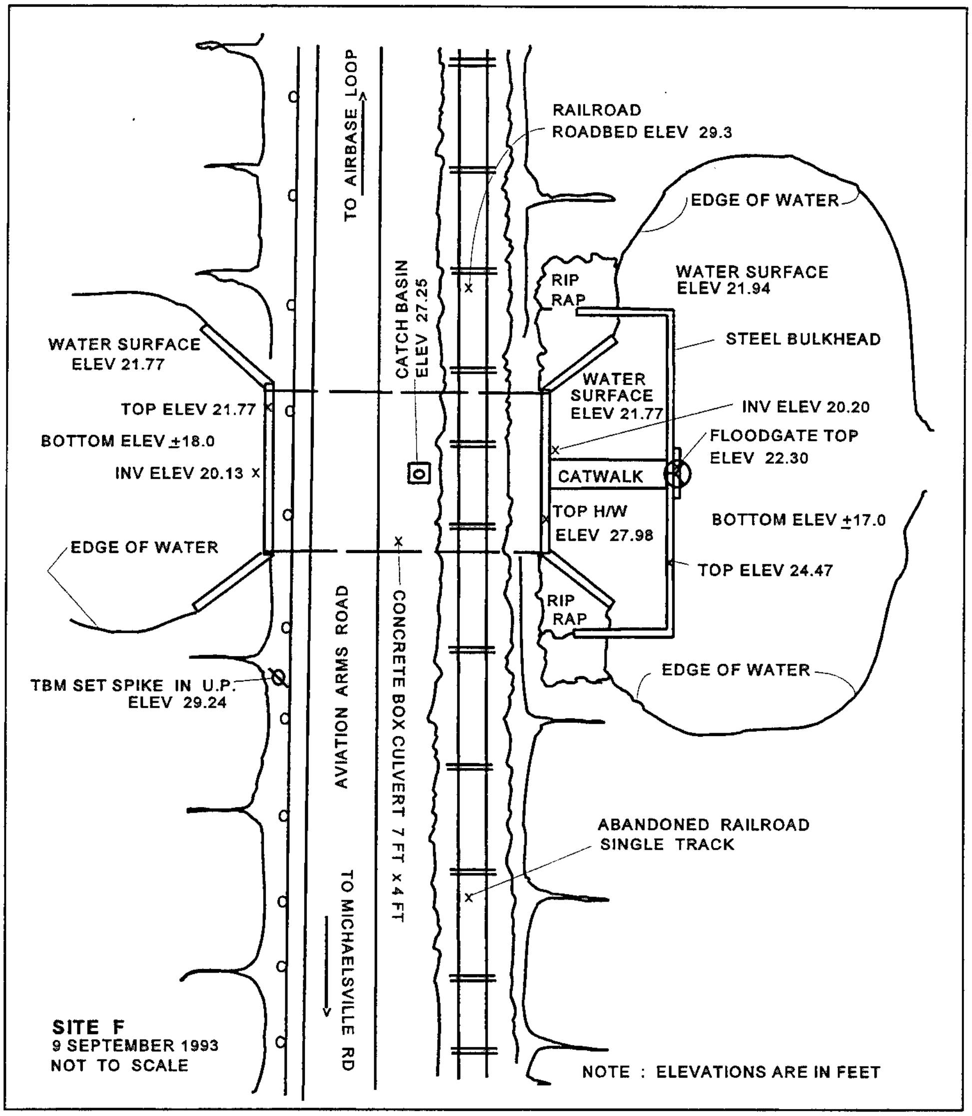
Site C. Gravel road crossing the western tributary of Romney Creek between the TRAAV and the 3 Mile Test Track



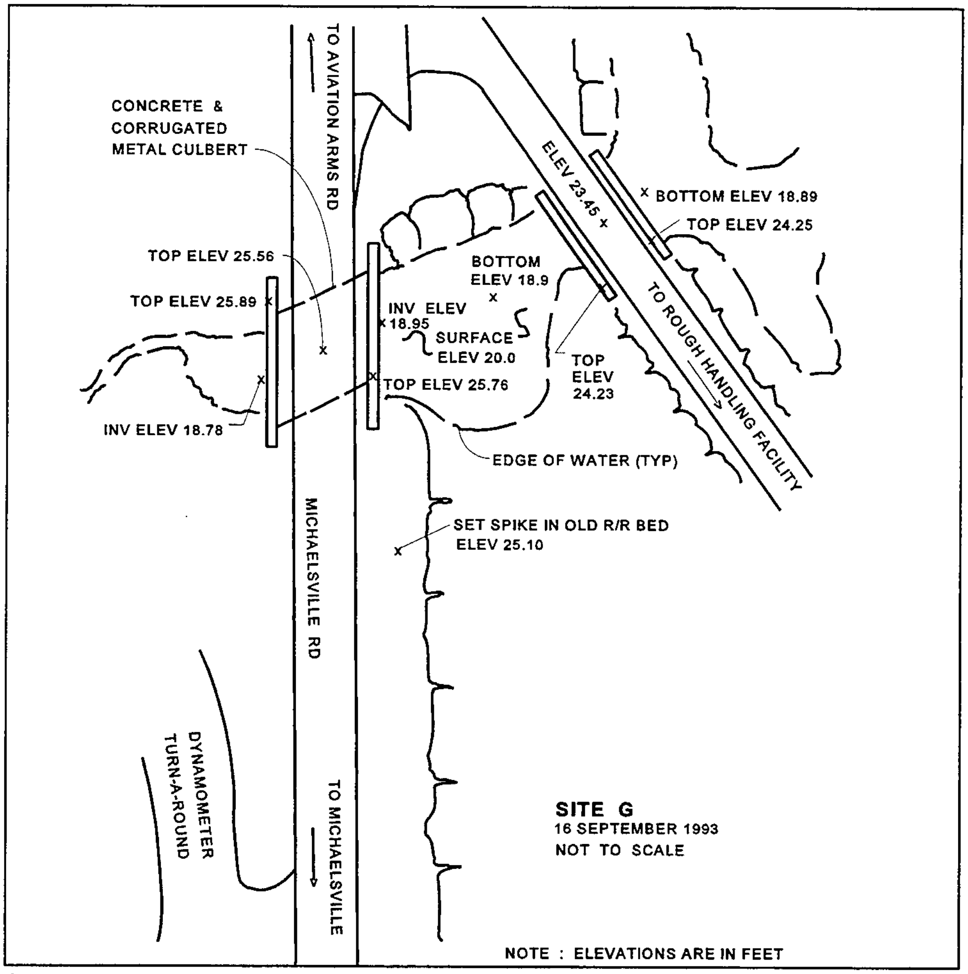
Site D. Gravel road with multiple culverts approximately 350 yd directly off the south end of Runway 22/04



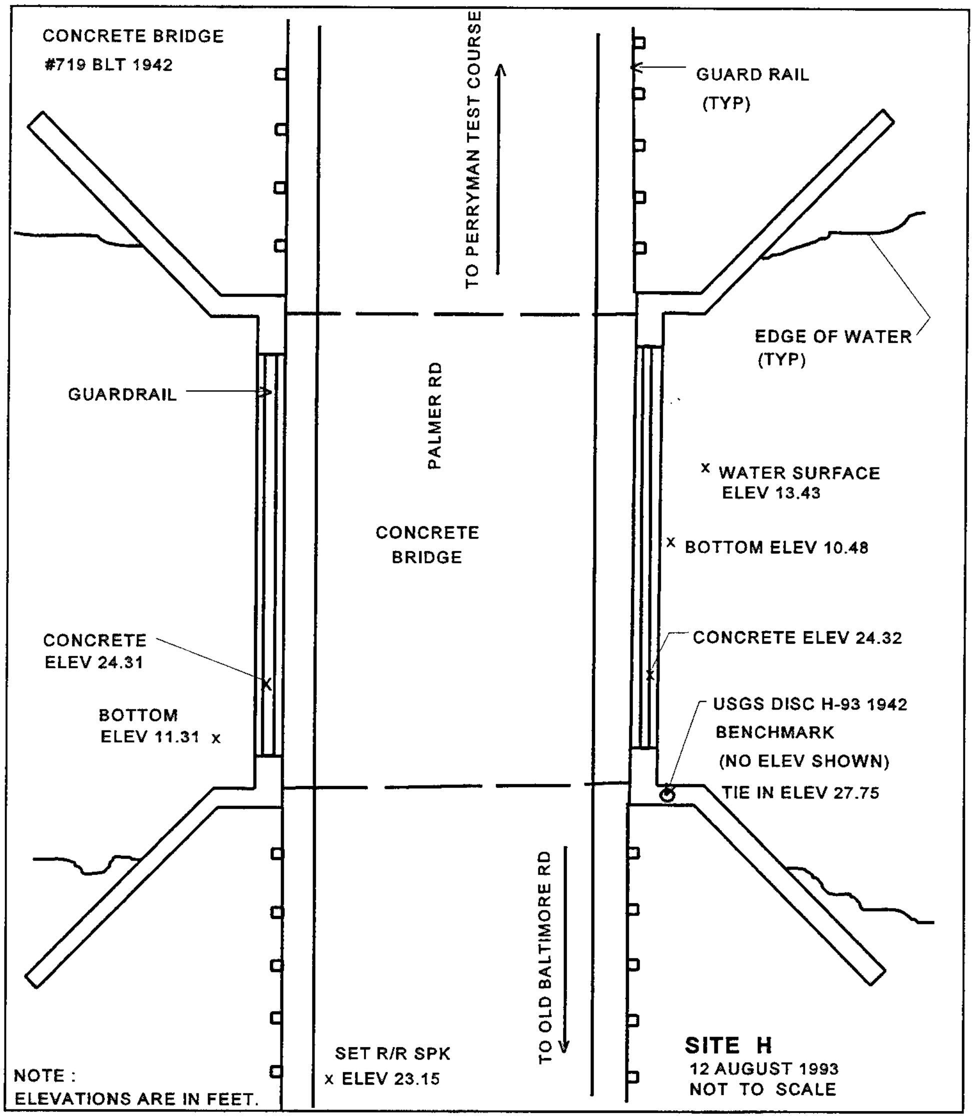
Site E. Point along Airbase Loop Road near Phillips Army Airfield Landfill where drainage from the airfield crosses under the road into the marshy east of the landfill



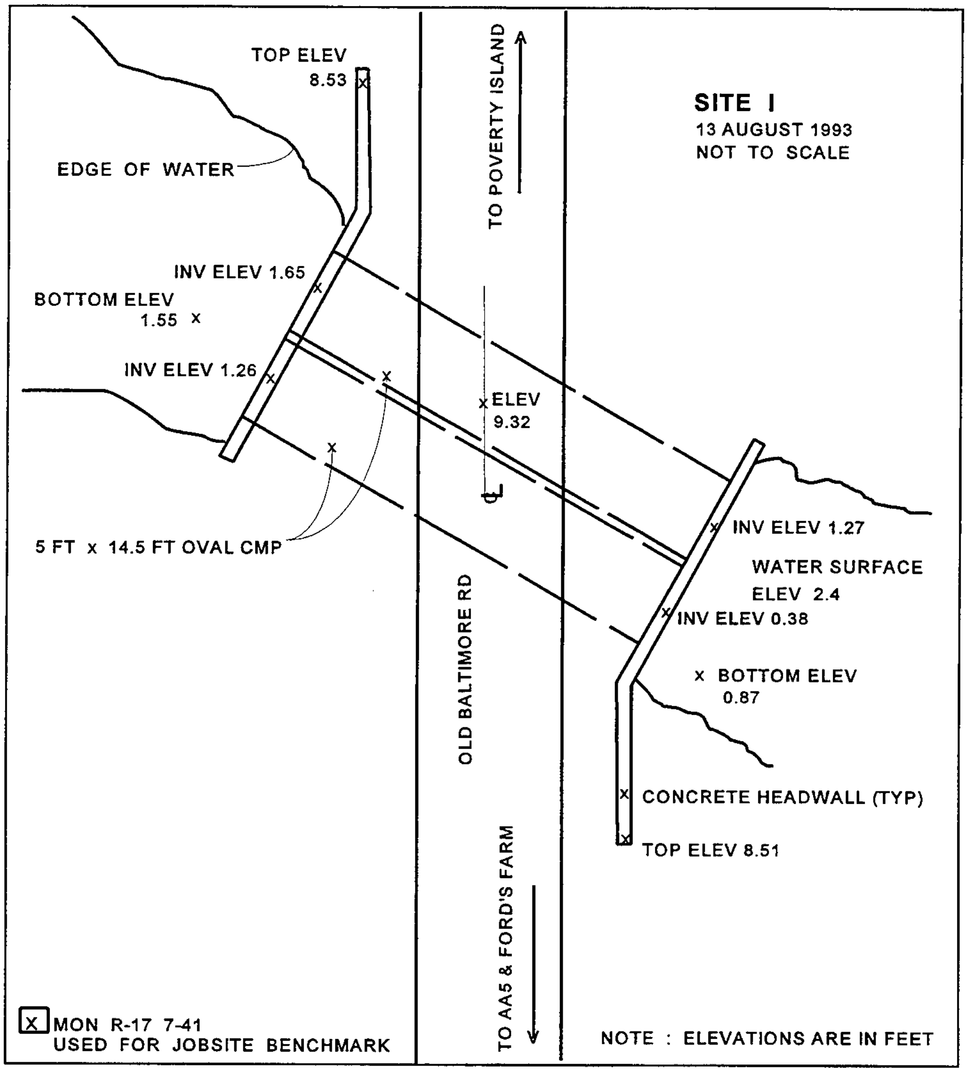
Site F. Point along Avaition Arms Road where the eastern tributary of Romney Creek crosses under the road



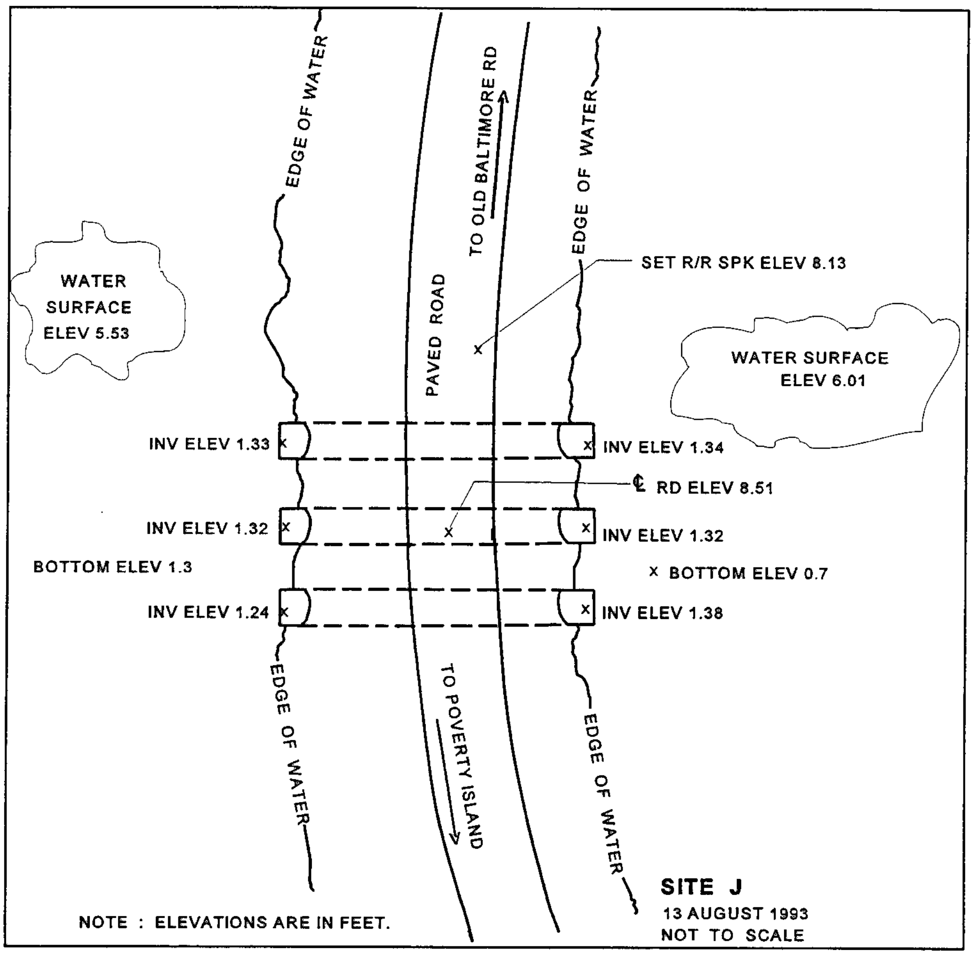
Site G. Point where a tributary of Romney Creek crosses beneath Michaelsville Road toward the closed Dynamometer Test Track



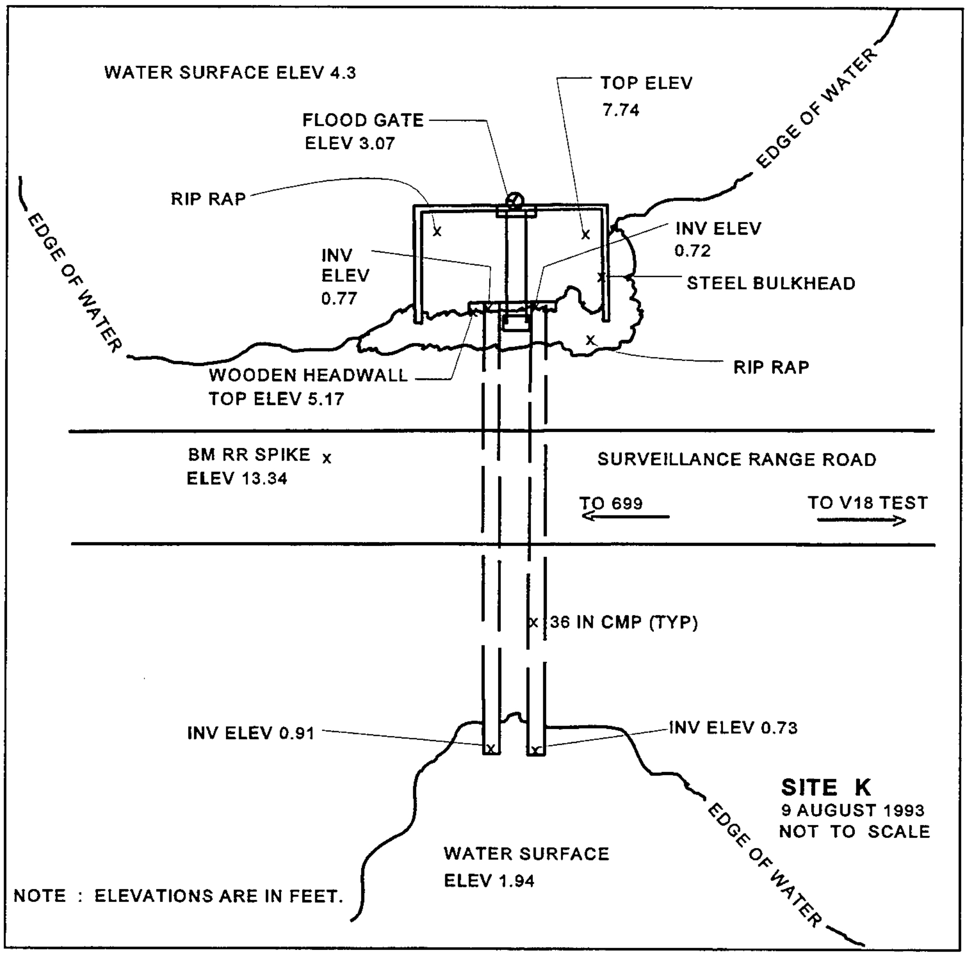
Site H. Point along Palmer Road where Romney Creek crosses beneath the road



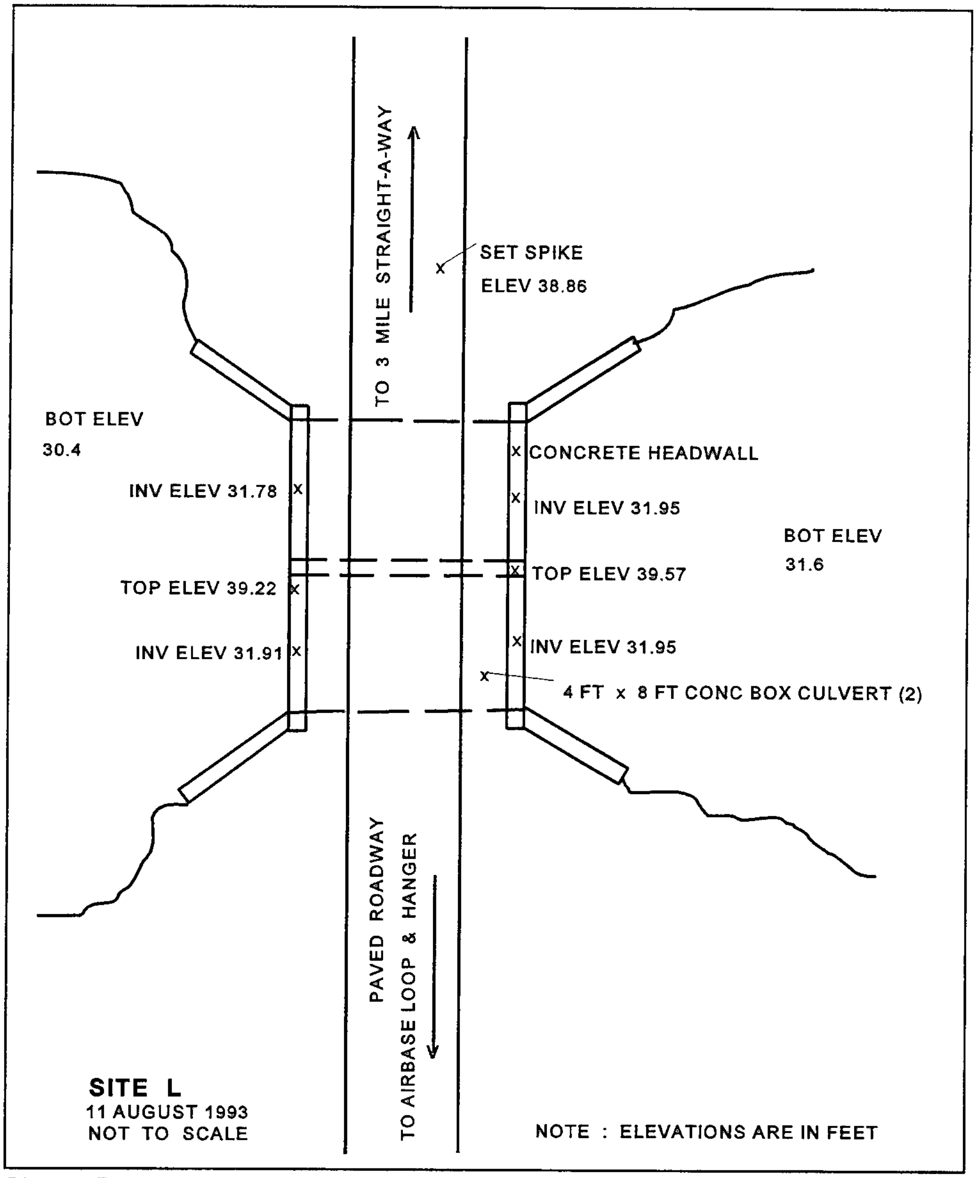
Site I. Point along Old Baltimore Road where Romney Creek crosses beneath the road



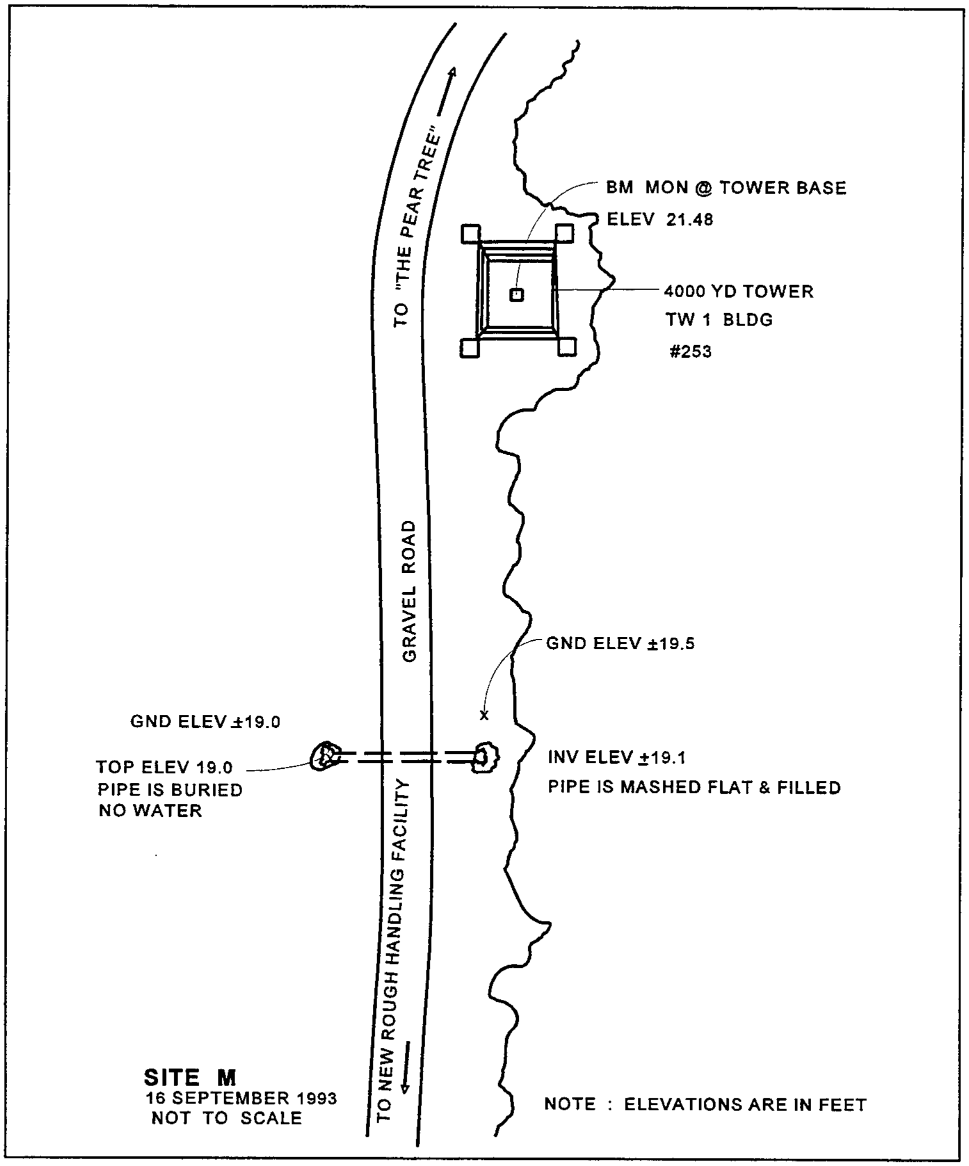
Site J. Point where Romney Creek crosses beneath the road leading from Old Baltimore Road to Poverty Island area



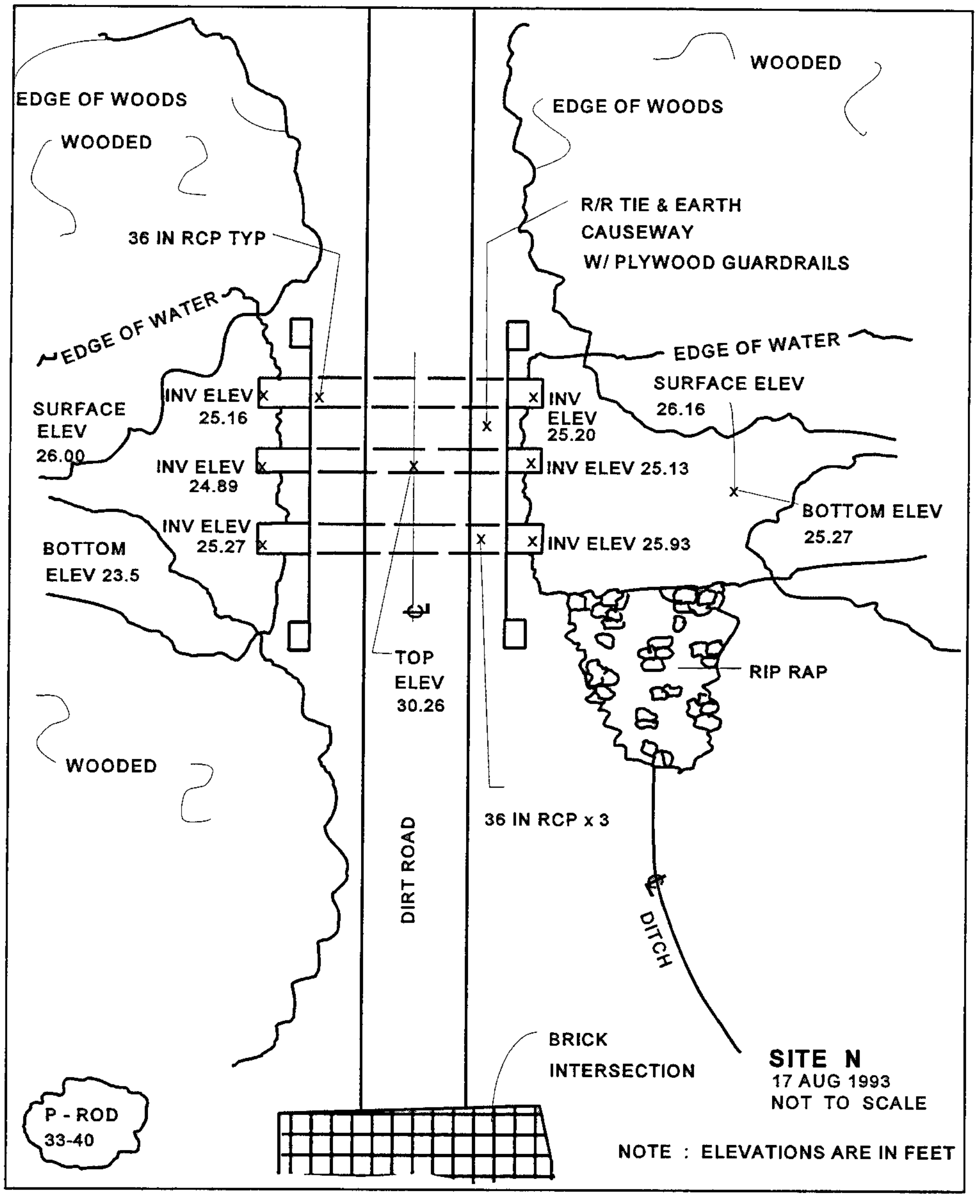
Site K. Point where Woodrest Creek crosses beneath Surveillance Range Road. Culverts or other inlets control flow here and cause the impoundment of water on the upstream side of the road.



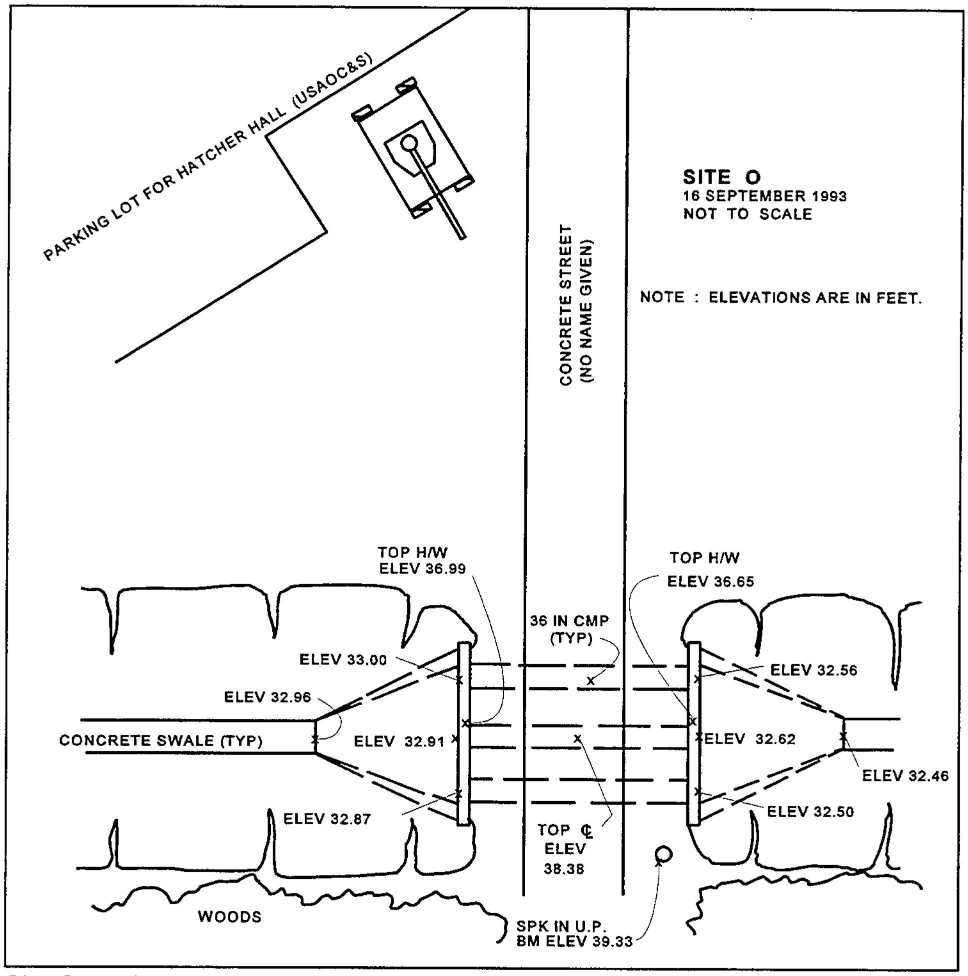
Site L. Point along the paved road between Phillips Army Airfield and the 3 Mile Test Track where the western tributary of Romney Creek crosses beneath the road



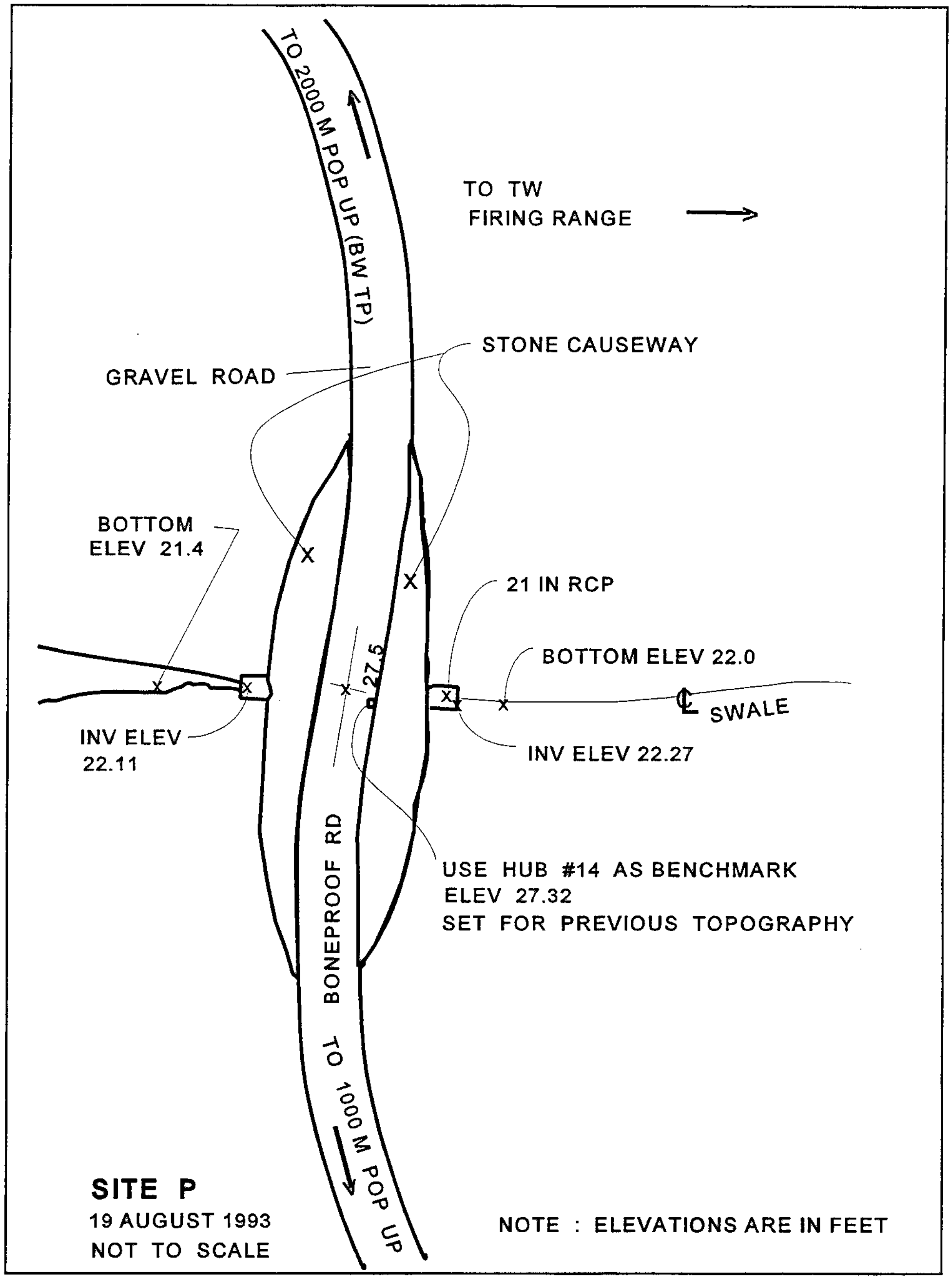
Site M. Point along unnamed road near Building T-283 where an upper reach of Mosquito Creek crosses beneath the road



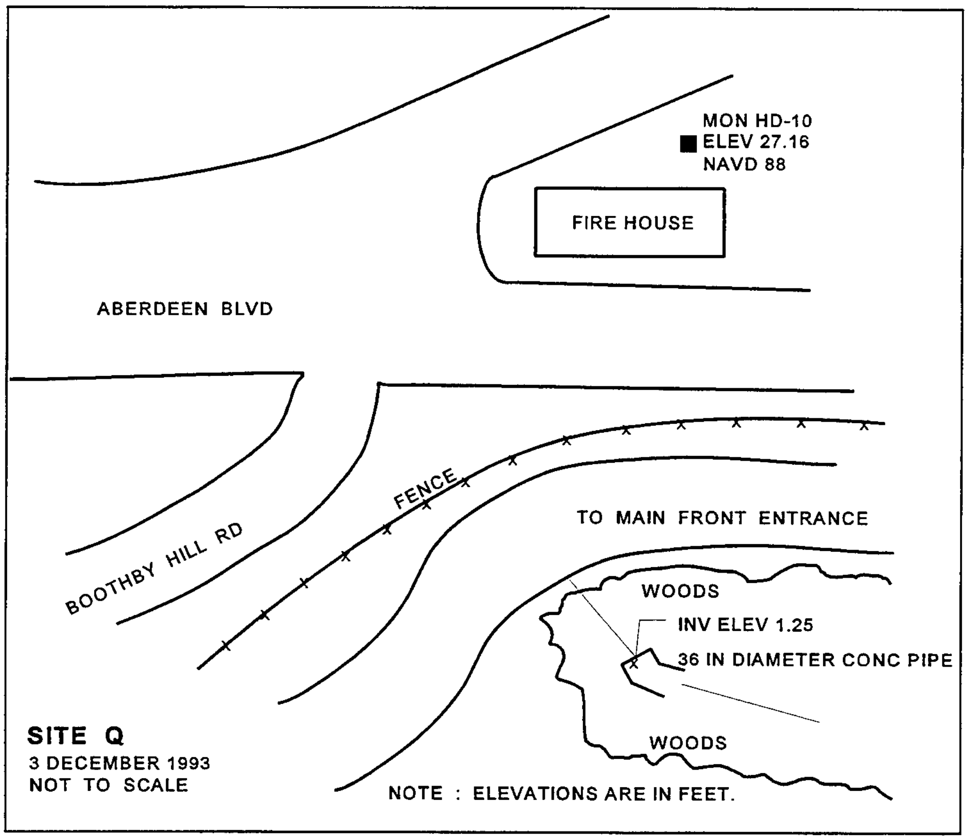
Site N. Point along Convey Road where the upper tributary of Romney Creek crosses beneath the road



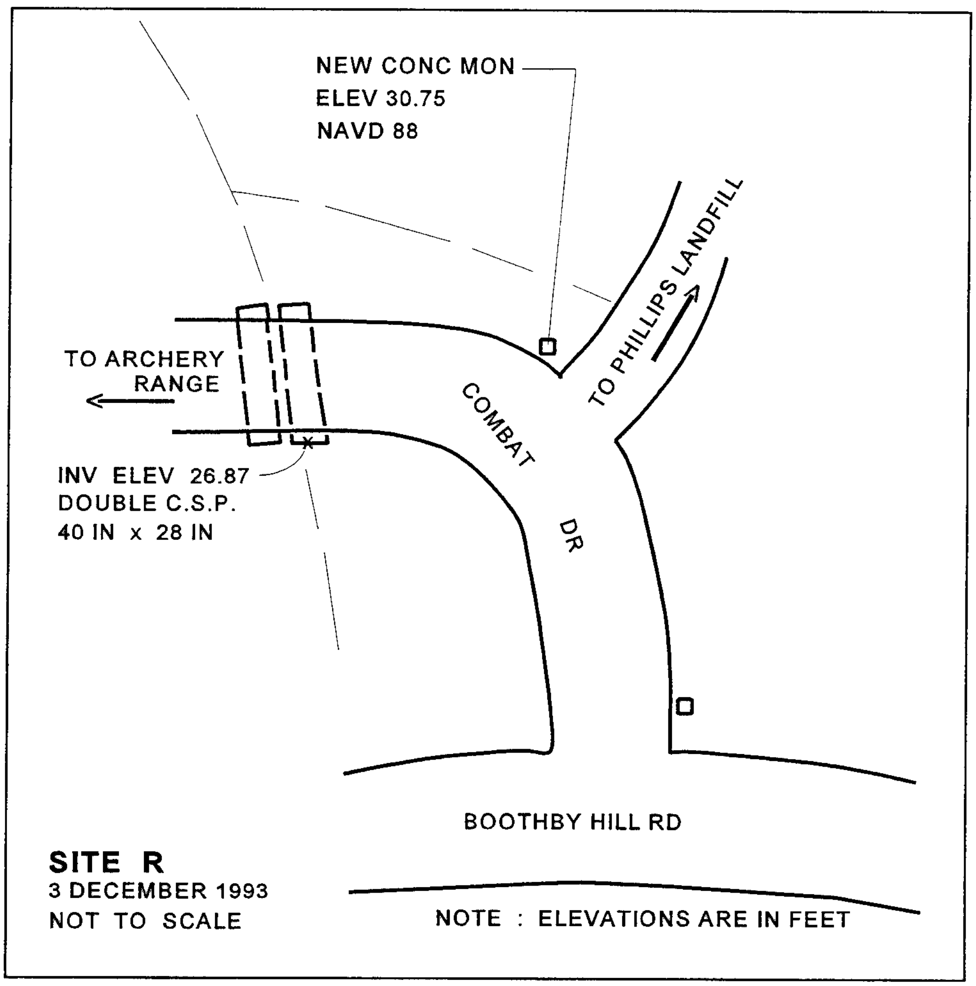
Site O. Point along School Road where an upper tributary of Romney Creek crosses beneath the road



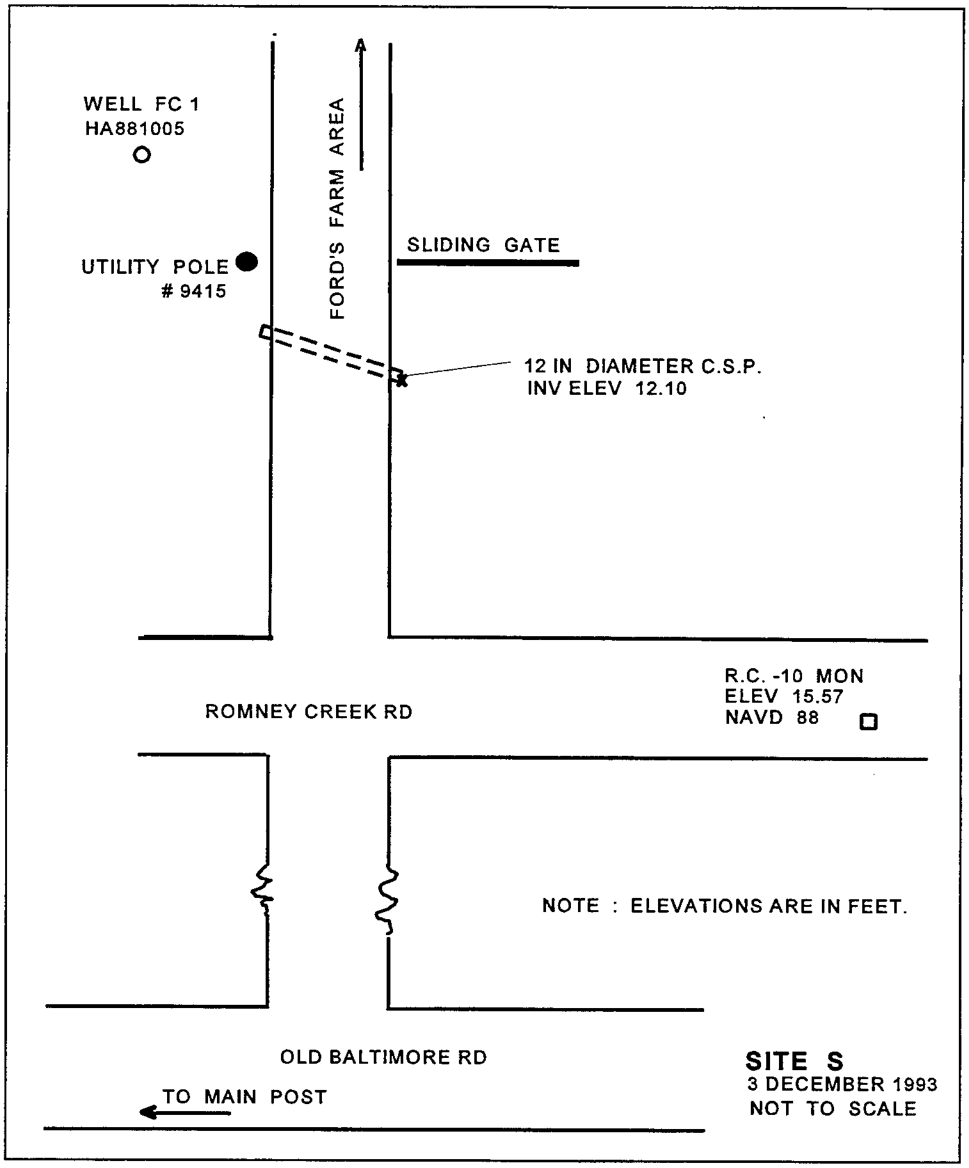
Site P. Site along Bomb Proof Road where an upper tributary of Woodrest Creek crosses beneath the road



Site Q. Point where surface drainage flows under Aberdeen Boulevard, near the intersection of Aberdeen Boulevard and Boothby Hill Road, into Swan Creek



Site R. Point along Combat Drive where a drainage of the eastern tributary of Romney Creek crosses beneath the road approximately 50 yd past the entrance to the Phillips Army Airfield Landfill

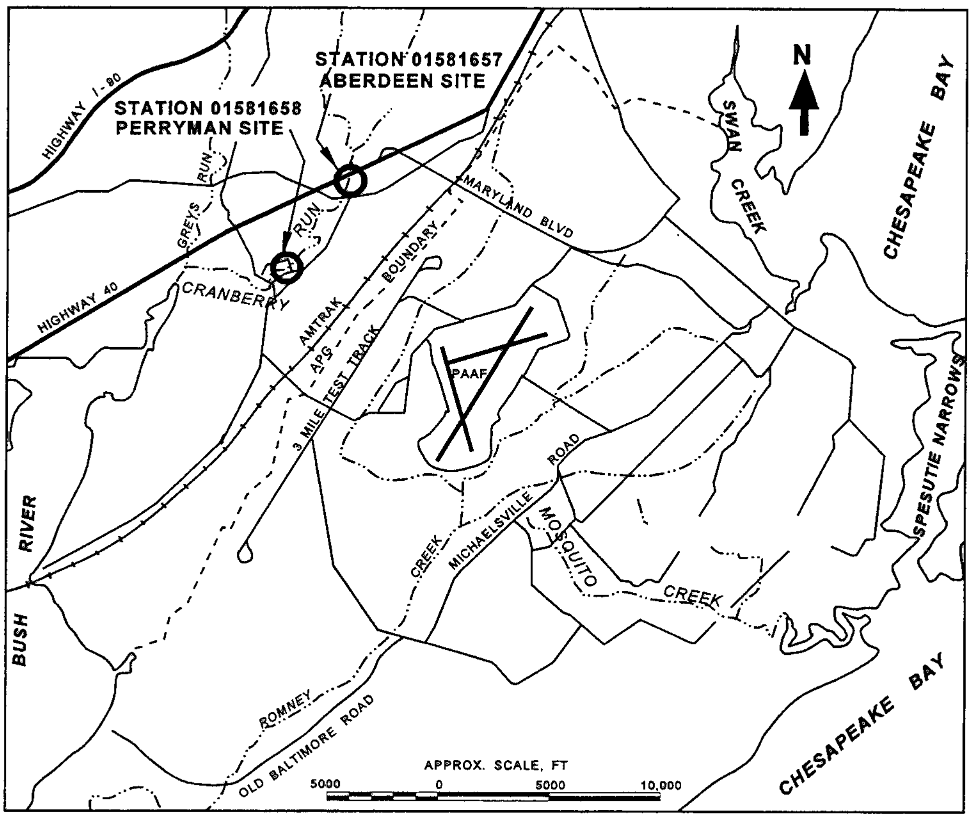


Site S. Tributary of Bridge Creek crossing beneath the road to Ford's Farm area approximately 500 ft east of Romney Creek Road

Appendix F

Stream Gauge Data

USGS stream gauge data were taken from the Bush River Basin, Maryland, stream gauge Station 01581657 on Cranberry Run in Aberdeen and Station 01581658 on Cranberry Run in Perryman. The data in Appendix F are copies of USGS data sheets.



Location of USGS stream gauge stations northwest of APG-AA

01581657 CRANBERRY RUN AT ABERDEEN, MD

LOCATION.--Lat 39°29′22″, long 76°11′32″, Harford County, Hydrologic Unit 02060003, on left bank at downstream side of bridge on U. S. Highway 40, 2.0 mi southwest of intersection with State Highway 132, and 2.1 mi upstream from mouth.

DRAINAGE AREA.--4.16 mi^2.

PERIOD OF RECORD.--October 1987 to September 1989 (discontinued).

GAGE.--Water-stage recorder and concrete block control. Elevation of gage is 25 ft above National Geodetic Vertical Datum of 1929, from topographic map.

REMARKS.--Records good except those for estimated daily values (periods of backwater from unknown sources and periods of doubtful record), which are fair. Several measurements of water temperature were made during the year. Water-quality records for some prior years have been collected at this location.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 443 ft^3/s, Nov. 28, 1988, gage height, 5.71 ft; minimum discharge, 0.11 ft^3/s, Aug. 14, 15, 17, 1988; minimum daily discharge, 0.16 ft^3/s, Aug. 14, 1988.

EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 300 ft^3/s and maximum (*):

Date	Time	Discharge (ft^3/s)	Gage height (ft)	Date	Time	Discharge (ft^3/s)	Gage height (ft)
Nov. 28	0115	*443	*5.71	May 24	0015	333	4.71
May 2	0600	338	4.76	June 9	2400	430	5.59
May 6	0330	360	4.96	July 20	0715	386	5.20

Minimum discharge, 0.24 ft^3/s, Oct. 10, 11, 12.

REVISIONS.--The maximum discharge reported for water year 1988 has been revised to 413 ft^3/s, May 19, 1988, gage height, 5.05 ft, superseding figures published in the report for 1988. Peak discharge for Aug. 24, 1988 (2300 hours) has been revised to 394 ft^3/s, gage height, 5.27 ft. Peak discharge for Aug. 29, 1988 (1530 hours) has been revised to 336 ft^3/s, gage height, 4.74 ft.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1988 TO SEPTEMBER 1989
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.76	e3.5	3.9	2.5	2.7	3.6	12	8.3	e2.5	e2.0	2.8	.98
2	1.3	e1.5	3.1	4.4	2.5	3.1	6.4	92	e2.2	e1.8	2.2	1.1
3	1.1	e1.3	2.9	3.7	11	3.0	9.9	9.9	e1.9	e1.8	1.8	1.1
4	.47	e1.3	2.5	2.8	9.9	2.9	6.1	5.1	e1.9	e3.8	1.6	1.0
5	.41	e2.2	2.3	1.9	4.9	4.1	10	35	e1.8	e32	1.5	.95
6	.41	e2.4	2.2	2.0	3.9	24	22	102	e6.0	e40	1.3	1.0
7	.35	e1.6	2.1	2.2	3.3	9.4	10	21	e18	e17	1.3	e1.1
8	.35	e1.4	2.0	13	2.8	4.8	10	9.9	e5.0	5.1	1.3	e1.2
9	.33	e1.4	1.9	14	2.4	6.5	10	e6.0	57	2.9	1.1	e1.2
10	.31	e1.4	1.7	7.4	2.1	7.1	5.0	e28	47	2.3	1.1	e1.2
11	.35	e1.5	1.6	5.7	2.1	6.1	3.7	e16	6.2	2.0	1.9	e1.2
12	.35	e1.4	1.3	46	2.2	5.1	e3.4	e9.0	3.4	1.7	2.9	e1.2
13	.49	e3.0	1.3	14	2.0	3.6	e3.2	e6.0	3.1	7.2	1.9	e1.4
14	.69	e1.6	1.4	6.5	19	3.4	e3.0	e6.0	3.8	3.4	1.5	1.2
15	.70	e1.1	1.6	51	14	3.2	15	e5.5	3.8	1.8	1.4	1.2
16	1.3	1.4	1.4	11	15	2.8	13	e22	3.3	e13	1.3	e5.0
17	1.2	32	1.2	6.3	6.2	2.6	5.4	e18	6.9	5.4	1.3	2.6
18	e.80	4.7	1.2	4.9	4.7	3.8	4.7	e6.0	4.2	2.6	1.3	.93
19	e.90	6.8	1.2	4.1	4.0	3.3	9.1	e4.6	2.2	1.9	6.3	e21
20	e1.0	39	1.3	3.6	3.4	3.3	4.2	e4.0	6.0	66	1.8	7.9
21	17	9.7	2.6	2.8	64	14	3.1	e3.4	19	19	1.6	4.8
22	20	3.9	2.0	2.4	33	5.6	e3.0	e3.0	8.7	6.4	1.3	4.4
23	2.0	2.9	3.2	2.5	12	3.7	e2.6	e45	40	3.6	1.1	2.2
24	2.5	2.6	5.2	2.5	6.6	99	e2.4	51	12	2.4	1.0	1.9
25	1.7	2.2	5.0	2.5	4.5	18	e2.3	e8.0	6.0	1.9	1.2	1.4
26	1.6	2.0	2.5	2.9	5.1	8.9	e2.2	e5.0	3.3	e30	1.0	e11
27	1.4	11	2.1	3.2	5.3	5.9	e2.0	16	e2.8	3.7	1.1	2.1
28	e1.3	106	3.7	2.5	4.8	5.0	e1.8	e6.0	e2.8	2.4	1.2	1.4
29	e1.2	9.6	3.1	2.4	---	4.4	e3.6	e3.8	e2.5	1.8	1.6	1.5
30	e1.1	5.4	2.3	4.3	---	8.9	e3.4	e3.0	e2.2	2.0	2.8	1.2
31	e1.1	---	2.2	3.2	---	42	---	e2.8	---	8.5	1.2	---
TOTAL	64.47	265.8	72.0	238.2	253.4	321.1	192.5	561.3	285.5	295.4	52.7	86.36
MEAN	2.08	8.86	2.32	7.68	9.05	10.4	6.42	18.1	9.52	9.53	1.70	2.88
MAX	20	106	5.2	51	64	99	22	102	57	66	6.3	21
MIN	.31	1.1	1.2	1.9	2.0	2.6	1.8	2.8	1.8	1.7	1.0	.93
CFSM	.50	2.13	.56	1.85	2.18	2.49	1.54	4.35	2.29	2.29	.41	.69
IN.	.58	2.38	.64	2.13	2.27	2.87	1.72	5.02	2.55	2.64	.47	.77

CAL YR 1988 TOTAL 2115.31 MEAN 5.78 MAX 115 MIN .16 CFSM 1.39 IN. 18.92
WTR YR 1989 TOTAL 2688.73 MEAN 7.37 MAX 106 MIN .31 CFSM 1.77 IN. 24.04

01581658 CRANBERRY RUN AT PERRYMAN, MD

LOCATION.--Lat 39°28'42", long 76°12'08", Harford County, Hydrologic Unit 02060003, on right bank 150 ft downstrea from bridge on Mayberry Road, 0.5 mi north of Perryman, and 1.0 mi upstream from mouth.

DRAINAGE AREA.--5.22 mi^2.

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--May 1987 to September 1988.

GAGE.--Water-stage recorder and concrete block control. Elevation of gage is 6.6 ft above National Geodetic Vertical Datum of 1929.

REMARKS.--Water-discharge records good except those for estimated daily discharges, which are fair.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 714 ft^3/s, Sept. 9, 1987, gage height, 6.20 ft, from floodmarks; minimum discharge, 0.39 ft^3/s, Aug. 23, 1987; minimum daily discharge, 0.50 ft^3/s, Aug. 21, 1987.

EXTREMES FOR CURRENT PERIOD.--Peak discharges greater than base discharge of 400 ft^3/s and maximum (*):

Date	Time	Discharge (ft^3/s)	Gage height (ft)	Date	Time	Discharge (ft^3/s)	Gage height (ft)
Sept. 9, 1987	0015	*714	*6.20	May 18, 1988	0800	430	4.90
Sept. 13, 1987	0130	Unknown	Unknown	May 19, 1988	0830	*513	*5.20
Feb. 12, 1988	0530	475	5.05	Aug. 24, 1988	2345	506	5.17

May to September 1987: Minimum discharge, 0.39 ft^3/s, Aug. 23.

Water year 1988: Minimum discharge, 0.59 ft^3/s, July 7, 8.

DISCHARGE, IN CUBIC FEET PER SECOND, MAY 1987 TO SEPTEMBER 1987
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	---	---	---	---	---	---	---	2.2	1.3	11	.62	.98
2	---	---	---	---	---	---	---	2.2	1.2	9.4	.64	.64
3	---	---	---	---	---	---	---	2.4	1.2	2.6	.64	.62
4	---	---	---	---	---	---	---	21	10	1.5	.64	.58
5	---	---	---	---	---	---	---	7.6	5.8	1.3	.67	.60
6	---	---	---	---	---	---	---	4.0	1.9	1.1	.76	.98
7	---	---	---	---	---	---	---	3.0	1.5	1.1	.70	1.5
8	---	---	---	---	---	---	---	2.5	1.4	1.3	.72	74
9	---	---	---	---	---	---	---	2.2	4.7	2.5	.74	e34
10	---	---	---	---	---	---	---	1.9	3.0	.98	.60	2.0
11	---	---	---	---	---	---	---	1.8	1.5	.85	.54	1.4
12	---	---	---	---	---	---	---	2.0	1.4	3.9	.54	18
13	---	---	---	---	---	---	---	2.0	1.4	2.1	.54	106
14	---	---	---	---	---	---	---	1.4	1.4	2.1	.54	7.4
15	---	---	---	---	---	---	---	5.0	1.2	1.5	.55	3.0
16	---	---	---	---	---	---	---	2.9	1.5	.97	.64	2.7
17	---	---	---	---	---	---	---	1.8	1.2	.97	.64	1.9
18	---	---	---	---	---	---	---	1.7	1.1	.93	.64	43
19	---	---	---	---	---	---	---	3.2	.97	.85	.64	11
20	---	---	---	---	---	---	---	20	.97	.83	.62	4.3
21	---	---	---	---	---	---	---	10	5.9	.74	.50	3.0
22	---	---	---	---	---	---	---	4.1	3.9	.74	1.1	3.0
23	---	---	---	---	---	---	---	2.9	1.9	.74	.51	2.0
24	---	---	---	---	---	---	---	2.5	1.2	.74	.54	1.6
25	---	---	---	---	---	---	---	2.1	1.1	.74	.60	1.4
26	---	---	---	---	---	---	---	2.0	.99	.80	.64	1.3
27	---	---	---	---	---	---	---	2.2	1.2	.82	.79	1.2
28	---	---	---	---	---	---	---	2.0	.99	.69	.74	1.2
29	---	---	---	---	---	---	2.2	1.6	.85	.55	.72	1.0
30	---	---	---	---	---	---	2.2	1.4	1.1	.59	.64	1.3
31	---	---	---	---	---	---	---	1.4	---	.64	.79	---
TOTAL	---	---	---	---	---	---	---	123.0	63.77	55.57	20.19	331.60
MEAN	---	---	---	---	---	---	---	3.97	2.13	1.79	.65	11.1
MAX	---	---	---	---	---	---	---	21	10	11	1.1	106
MIN	---	---	---	---	---	---	---	1.4	.85	.55	.50	.58
CFSM	---	---	---	---	---	---	---	.76	.41	.34	.12	2.12
IN.	---	---	---	---	---	---	---	.88	.45	.40	.14	2.36

e Estimated

01581658 CRANBERRY RUN AT PERRYMAN, MD--Continued

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1.4	e1.1	8.0	4.4	8.3	3.8	4.1	4.6	2.6	.91	1.0	1.3
2	1.5	e1.1	4.7	4.2	15	3.7	3.8	4.1	2.7	.89	1.0	1.2
3	2.8	e1.0	3.5	3.0	14	3.7	3.7	3.7	2.6	.80	1.0	1.0
4	e1.5	e1.0	4.0	3.6	21	28	3.7	4.3	2.6	.80	.91	33
5	e1.0	e1.0	3.4	3.0	8.9	17	3.4	30	2.6	.80	.91	13
6	e1.0	e1.0	3.2	2.1	5.1	7.2	3.2	48	2.4	.80	.91	3.3
7	3.4	e1.0	3.0	1.9	4.5	5.8	16	15	2.2	.75	.81	2.1
8	1.0	e1.0	2.9	2.4	3.7	4.9	13	7.2	3.3	.70	.88	1.6
9	.85	e1.1	2.9	2.5	3.7	4.6	6.3	5.6	2.3	.77	.80	1.5
10	.80	e8.0	2.9	2.4	3.7	4.5	4.8	5.6	2.4	.78	.80	1.3
11	.86	6.0	3.8	2.3	4.9	3.9	4.2	16	1.9	1.9	.80	1.3
12	1.0	4.3	3.0	2.4	138	3.7	3.8	8.4	1.7	5.7	.80	1.2
13	1.0	3.6	2.5	2.5	13	4.1	3.6	5.0	1.3	1.1	.80	3.8
14	1.0	2.3	2.4	2.5	6.7	3.9	3.4	3.3	1.2	.89	.80	1.5
15	1.0	1.5	20	2.0	7.2	3.5	3.2	2.6	1.1	.80	.80	1.2
16	1.0	1.3	11	2.0	35	3.3	4.2	2.4	1.0	.80	.80	1.0
17	1.0	1.2	4.7	1.9	8.4	3.2	3.4	8.1	1.1	.80	.80	1.0
18	1.1	1.8	3.5	8.7	6.4	3.2	4.2	123	1.2	.85	.80	1.1
19	1.2	1.1	3.2	8.3	31	3.2	4.9	121	1.2	1.2	1.0	1.2
20	1.2	.94	5.6	81	45	3.2	3.7	20	1.1	4.9	1.6	1.2
21	1.2	1.2	4.4	20	10	2.9	3.3	11	1.0	3.1	1.0	1.2
22	1.2	1.4	3.4	9.5	6.0	2.9	2.9	7.2	1.0	1.9	.80	1.1
23	1.2	1.4	3.3	6.3	5.7	2.9	2.9	9.8	1.0	24	.81	1.0
24	1.2	1.4	2.9	5.0	5.2	2.9	4.3	17	1.0	8.1	49	1.2
25	e1.2	1.3	3:0	11	4.6	2.9	3.2	19	.91	1.4	32	5.4
26	e1.2	1.5	13	15	4.3	30	3.1	7.2	.91	14	2.0	1.6
27	7.0	1.6	5.2	6.1	4.3	28	13	5.0	1.0	6.5	1.3	1.3
28	7.7	2.2	4.6	5.2	4.4	7.0	38	4.2	1.0	4.3	1.2	1.1
29	1.6	56	7.9	3.7	4.1	5.2	7.3	3.7	.90	1.7	45	1.0
30	1.3	49	4.1	3.7	---	4.5	5.6	3.1	.83	1.3	6.0	.91
31	e1.2	---	3.3	6.5	---	4.2	---	2.8	---	1.1	2.1	---
TOTAL	51.61	158.34	153.3	235.1	432.1	211.8	184.2	527.9	48.05	94.34	159.33	89.61
MEAN	1.66	5.28	4.95	7.58	14.9	6.83	6.14	17.0	1.60	3.04	5.14	2.99
MAX	7.7	56	20	81	138	30	38	123	3.3	24	49	33
MIN	.80	.94	2.4	1.9	3.7	2.9	2.9	2.4	.83	.70	.80	.91
CFSM	.32	1.01	.95	1.45	2.85	1.31	1.18	3.26	.31	.58	.98	.57
IN.	.37	1.13	1.09	1.68	3.08	1.51	1.31	3.76	.34	.67	1.14	.64

WTR YR 1988 TOTAL 2345.68 MEAN 6.41 MAX 138 MIN .70 CFSM 1.23 IN. 16.72

e Estimated

01581658 CRANBERRY RUN AT PERRYMAN, MD--Continued

WATER-QUALITY RECORDS

PERIOD OF RECORD.--Water years 1987 to current year.

WATER QUALITY DATA, WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988

DATE	TIME	STREAM-FLOW, INSTAN-TANEOUS (CFS)	SPE-CIFIC CON-DUCT-ANCE (US/CM)	PH (STAND-ARD UNITS)	TEMPER-ATURE WATER (DEG C)	TEMPER-ATURE AIR (DEG C)	COLOR (PLAT-INUM-COBALT UNITS)	OXYGEN, DIS-SOLVED (MG/L)	CALCIUM DIS-SOLVED (MG/L AS CA)
APR									
25...	1245	2.8	204	6.9	12.5	15.0	--	14.4	9.8
AUG									
17...	1400	0.83	207	6.6	21.5	31.5	1	9.0	9.7

DATE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY WAT WH TOT IT FIELD MG/L AS CACO3	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	SILICA, DIS-SOLVED (MG/L AS SIO2)
APR								
25...	5.7	15	1.4	20	14	30	0.10	8.9
AUG								
17...	6.4	14	2.4	13	8.2	29	<0.10	8.4

DATE	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	NITRO-GEN, NO2+NO3 TOTAL (MG/L AS N)	PHOS-PHOROUS TOTAL (MG/L AS P)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE)	IRON, DIS-SOLVED (UG/L AS FE)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	CARBON, ORGANIC TOTAL (MG/L AS C)
APR									
25...	118	97	2.10	0.010	320	130	40	46	3.4
AUG									
17...	122	86	5.30	0.030	230	43	30	23	1.8

01581658 CRANBERRY RUN AT PERRYMAN, MD

LOCATION.--Lat 39°28'42", long 76°12'08", Harford County, Hydrologic Unit 02060003, on right bank 150 ft downstream from bridge on Mayberry Road, 0.5 mi north of Perryman, and 1.0 mi upstream from mouth.

DRAINAGE AREA.--5.22 mi^2.

PERIOD OF RECORD.--May 1987 to September 1989 (discontinued).

GAGE.--Water-stage recorder and concrete block control. Elevation of gage is 6.6 ft above National Geodetic Vertical Datum of 1929.

REMARKS.--Records good. Several measurements of water temperature were made during the year. Water-quality records for some prior periods have been collected at this location.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 714 ft^3/s, Sept. 9, 1987, gage height, 6.20 ft, from floodmarks; minimum discharge, 0.39 ft^3/s, Aug. 23, 1987; minimum daily discharge, 0.50 ft^3/s, Aug. 21, 1987.

EXTREMES FOR CURRENT YEAR.--Peak discharges greater than base discharge of 400 ft^3/s and maximum (*):

Date	Time	Discharge (ft^3/s)	Gage height (ft)	Date	Time	Discharge (ft^3/s)	Gage height (ft)
Nov. 28	0230	*584	*5.52	June 10	0100	543	5.33
May 2	0700	426	4.89	July 20	0815	475	5.05
May 6	0415	462	5.01				

Minimum discharge, 0.80 ft^3/s, Oct. 8.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1988 TO SEPTEMBER 1989
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.91	3.7	5.3	3.1	3.9	4.6	12	8.3	3.5	2.9	4.1	1.3
2	1.0	2.4	4.1	4.9	3.6	4.1	7.4	99	3.0	2.6	3.4	1.3
3	2.1	1.9	3.8	4.6	10	3.7	10	11	2.7	2.6	2.9	1.3
4	1.1	1.7	3.5	3.7	10	3.5	7.8	6.6	2.7	4.1	2.6	1.2
5	1.0	2.5	3.4	2.6	5.7	4.5	11	29	2.6	33	2.3	1.3
6	.99	4.2	3.3	2.7	5.0	23	22	113	8.3	42	2.0	1.4
7	.91	2.4	3.2	2.9	4.5	9.4	10	19	19	17	1.9	1.4
8	.89	1.9	3.0	13	4.0	5.7	11	9.0	6.7	6.2	1.9	1.5
9	.91	1.9	2.9	15	3.6	6.6	10	7.0	42	4.2	1.7	1.5
10	.91	1.9	2.5	7.6	3.2	7.3	6.8	30	66	3.6	1.8	1.5
11	.91	2.1	2.4	6.2	•3.2	6.6	5.6	17	7.0	3.1	2.8	1.5
12	.91	1.9	1.8	43	•3.2	5.8	5.1	9.2	4.8	2.7	3.9	1.5
13	.91	3.9	1.7	14	3.1	4.6	4.8	7.0	4.5	6.4	2.7	1.7
14	.91	2.4	1.7	6.8	18	4.3	4.3	7.2	4.8	4.6	2.1	1.5
15	1.0	1.5	1.9	48	13	4.3	14	6.2	5.3	3.1	1.9	1.5
16	1.5	1.7	1.8	10	15	3.7	12	23	4.7	13	1.9	4.2
17	1.4	32	1.7	6.9	6.8	3.4	6.4	19	7.4	6.7	1.7	4.3
18	1.0	6.1	1.6	5.7	5.6	4.4	5.8	7.7	5.6	4.1	1.7	1.6
19	1.1	6.7	1.5	5.2	5.0	4.4	9.4	5.6	3.6	3.3	5.9	21
20	1.2	38	1.6	4.9	4.7	4.0	5.7	4.9	6.0	73	3.0	8.7
21	12	11	3.1	4.0	59	14	4.7	4.1	18	17	2.3	4.6
22	25	5.5	2.9	3.5	33	6.7	4.1	3.7	10	7.2	1.9	5.2
23	2.9	4.2	3.8	3.7	12	5.3	3.7	43	43	5.2	1.7	2.6
24	3.6	3.6	5.4	3.7	7.1	90	3.4	62	12	3.8	1.5	2.0
25	2.5	3.2	5.8	3.7	5.3	19	3.3	9.5	7.3	3.2	1.5	1.5
26	2.2	3.0	3.2	4.1	5.8	9.5	3.2	6.5	5.2	30	1.3	11
27	1.7	7.5	2.7	4.4	5.9	7.3	2.9	16	4.1	5.2	1.3	2.8
28	1.7	135	4.0	3.8	5.8	6.6	2.6	7.4	4.1	3.8	1.3	1.7
29	1.6	10	3.9	3.7	---	6.1	4.7	4.9	3.7	2.9	1.4	1.7
30	1.5	6.5	2.9	5.2	---	8.5	4.5	4.1	3.1	3.0	3.2	1.5
31	1.5	---	2.7	4.5	---	39	---	3.8	---	8.1	1.5	---
TOTAL	77.76	310.3	93.1	255.1	265.0	329.9	218.2	603.7	320.7	327.6	71.1	95.8
MEAN	2.51	10.3	3.00	8.23	9.46	10.6	7.27	19.5	10.7	10.6	2.29	3.19
MAX	25	135	5.8	48	59	90	22	113	66	73	5.9	21
MIN	.89	1.5	1.5	2.6	3.1	3.4	2.6	3.7	2.6	2.6	1.3	1.2
CFSM	.48	1.98	.58	1.58	1.81	2.04	1.39	3.73	2.05	2.02	.44	.61
IN.	.55	2.21	.66	1.82	1.89	2.35	1.55	4.30	2.29	2.33	.51	.68

CAL YR 1988 TOTAL 2463.59 MEAN 6.73 MAX 138 MIN .70 CFSM 1.29 IN. 17.56
WTR YR 1989 TOTAL 2968.26 MEAN 8.13 MAX 135 MIN .89 CFSM 1.56 IN. 21.15

• Estimated

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1.AGENCY USE ONLY *(Leave blank)*	2.REPORT DATE	3.REPORT TYPE AND DATES COVERED
	September 1997	Final report

4.TITLE AND SUBTITLE
Conceptual Hydrogeologic Model of Aberdeen Proving Ground—Aberdeen Area, MD

5.FUNDING NUMBERS
PR PO94-13 and PO96-288

6.AUTHOR(S)
Charlie B. Whitten, Stanley M. Swartzel, S. Paul Miller, and Kelly Blough

7.PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199; Advanced Sciences, Inc., HQ USAADACENFB, ATT: ZC-DOE-M 515B Blough, Fort Bliss, TX 79916

8.PERFORMING ORGANIZATION REPORT NUMBER
Technical Report GL-97-16

9.SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Environmental Management Division
Directorate of Safety, Health, and Environment
Aberdeen Proving Ground, Aberdeen, MD

10.SPONSORING/MONITORING AGENCY REPORT NUMBER

11.SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a.DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b.DISTRIBUTION CODE

13.ABSTRACT *(Maximum 200 words)*

This report is a compilation of the existing hydrogeologic data for Aberdeen Proving Ground, Aberdeen Area (APG-AA). Using boring data, the top of the metamorphic bedrock, top of the Cretaceous sediments, and three Quaternary terraces have been mapped. Geologic cross sections of the western half of the APG-AA peninsula, showing the relationship between the bedrock, Cretaceous, and Quaternary units, have been constructed. The similar lithologies of the interbedded Lower Cretaceous Patapsco, Arundel, and Paxtuxent formations did not allow them to be mapped as separate units. Boring data from the Western Boundary Area study provided lithologic data to map the extent of the two oldest Quaternary terraces, Qt2 and Qt3. There was not sufficient data to accurately map the youngest Quaternary terrace, Qt1. Permeable aquifer zones in the Cretaceous units were identified in borings; however, available data did not allow them to be correlated over any appreciable distance on APG-AA. The Qt3 is a highly permeable water table aquifer. Water level data indicate that groundwater is moving vertically from the water table aquifer into the lower aquifer zones; however, the lower aquifer zones do not appear to be vertically or laterally well connected.

14.SUBJECT TERMS

Aberdeen Proving Ground—Aberdeen Area	Lithology	Quaternary terraces
Aquifer	Lower Cretaceous	
Groundwater	Potomac Group	

15.NUMBER OF PAGES
228

16.PRICE CODE

17.SECURITY CLASSIFICATION OF REPORT	18.SECURITY CLASSIFICATION OF THIS PAGE	19.SECURITY CLASSIFICATION OF ABSTRACT	20.LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		